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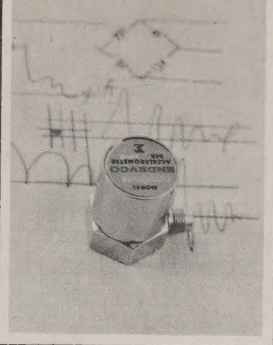
INSTRUCTION MANUAL

MODEL 4470 UNIVERSAL

SIGNAL CONDITIONING MODULE



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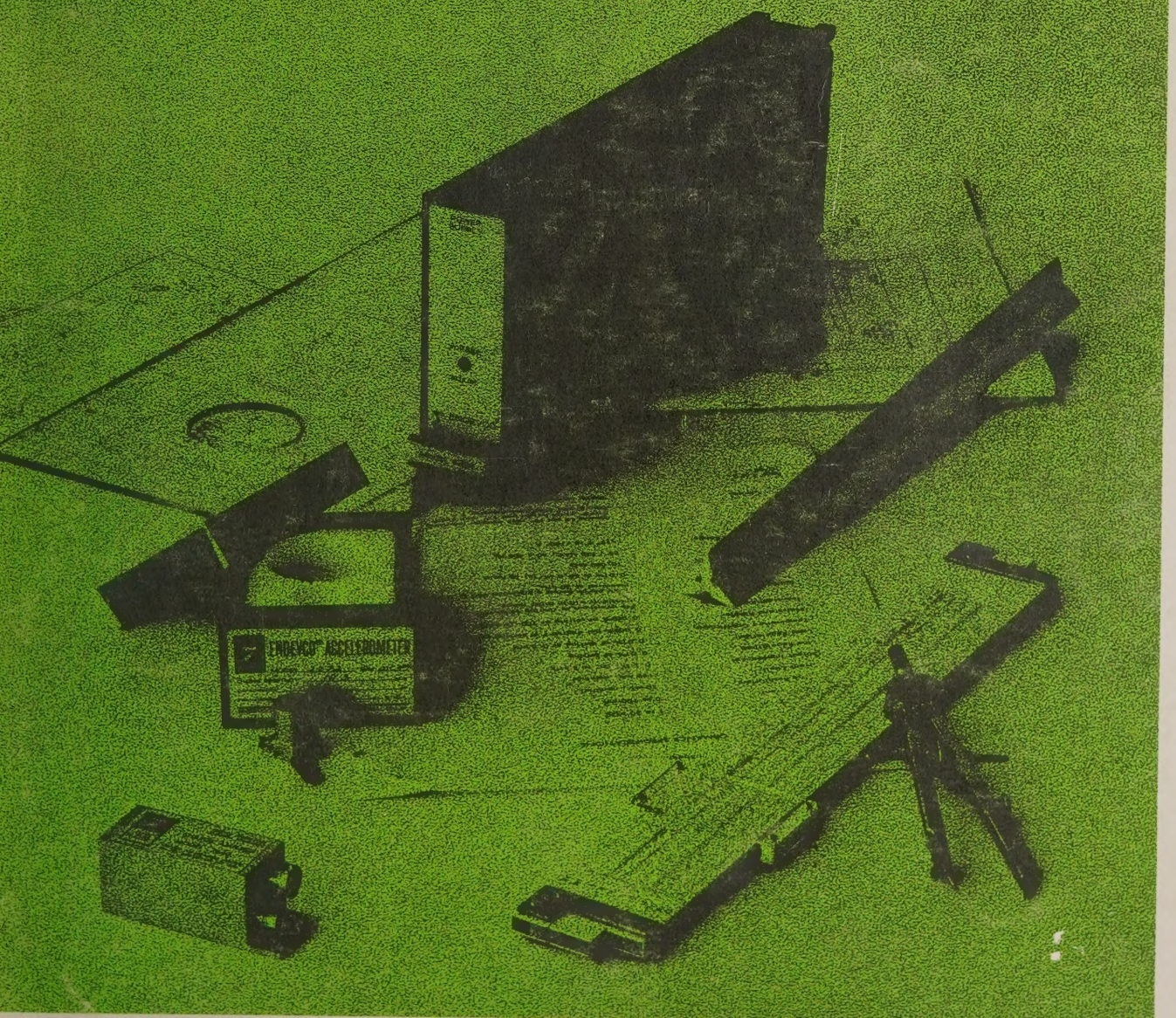

INSTRUCTION MANUAL FOR

MODEL 4470 UNIVERSAL
SIGNAL CONDITIONING MODULE

TABLE OF CONTENTS

1.0 GENERAL DESCRIPTION

1.1	Introduction	1
1.2	Input Devices	2
1.3	Output Devices	2
1.4	Mode Cards	2
1.5	Electrical Protection	3

2.0 PHYSICAL DESCRIPTION

2.1	Front Panel Controls	3
2.2	Rear Panel Connector	4
2.3	Mode Card Insertion	4
2.4	Model 4942 Rack Adapter	5
2.5	Model 4943 Rack Adapter	5
2.6	Bench Top Operation	5

3.0 CIRCUIT DESCRIPTION

4.0 OPERATING INSTRUCTIONS

4.1	Mounting	8
4.2	Electrical Connections	8
4.3	Power	10
4.4	Mode Cards	10
4.5	Relays for Remote Operation	10
4.6	Temperature	11

5.0 INSTALLATION AND CHECKOUT

5.1	Unpacking and Inspection	12
5.2	Installation	12
5.3	Connections	12
5.4	Checkout Procedure	12
5.5	Checkout with Voltage Regulation Card	13
5.6	Checkout with Current Regulation Card	17

6.0 MAINTENANCE 19

7.0 DRAWINGS AND ADDENDA 20

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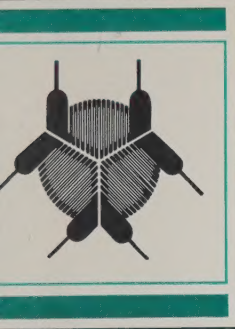
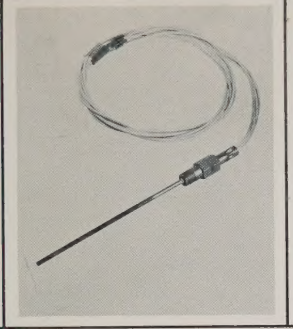
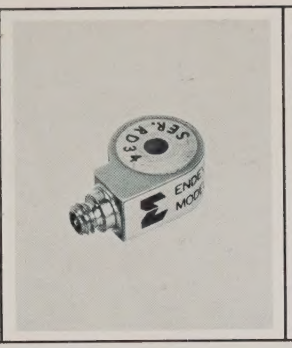
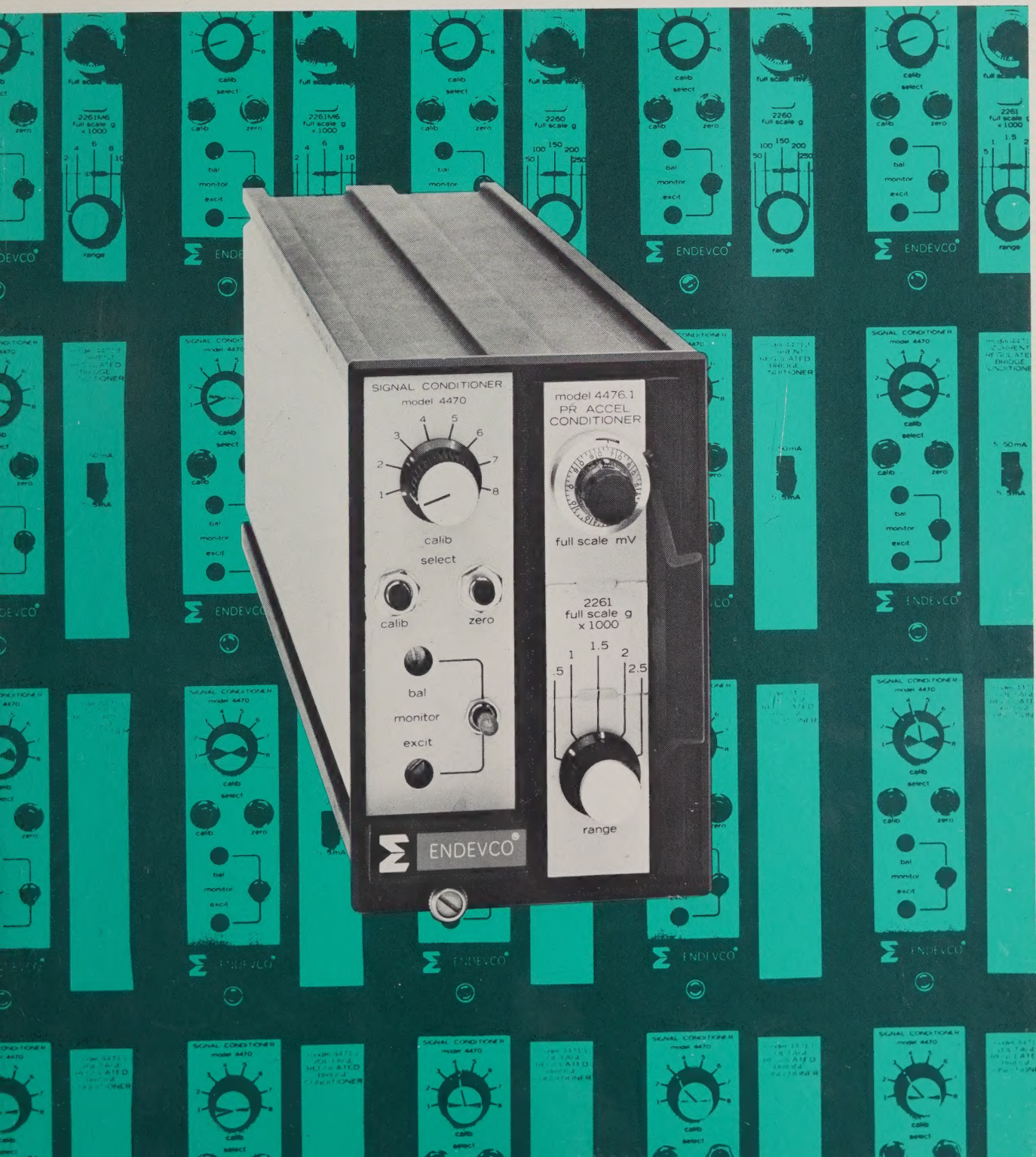






ENDEVCO

UNIVERSAL SIGNAL CONDITIONING SYSTEM SERIES 4470



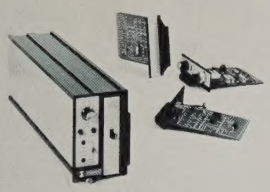
Endevco's new 4470 System is the latest expression of the Universal Signal Conditioning concept introduced with the Model 4401. Universal takes on a new meaning in the greatly expanded versatility of the 4470. In this latest version, the components of the system are all routed through the mode card for interconnection in the optimum conditioning circuit for the transducer being used. Insert a new card, and you have built yourself a new signal conditioner. Not only do you have a highly versatile system for today's diverse requirements, but the system is left open-ended to accommodate future needs that may not even be defined today. New cards will continue to be introduced as new signal conditioning needs arise, or you might want to design your own, but the heart of your system remains as up to date as the latest mode card.

The concept employed in the design of a Universal Signal Conditioning System says that components common to all or most operating modes should be located in the master module where all circuits can call upon them. Components used in only one or two modes should be located on the individual mode cards where they are needed. The rest of the operating modes are not burdened then by the cost of unused components. A further extension of this concept demands that all parts of the system be enclosed within a single shielded enclosure. In the 4470, this enclosure is the master module into which the individual mode cards are inserted. This results in the best possible shielding and consequently the best quality data.

This brochure, and the individual mode card data sheets that go with it, have been laid out to present a clear picture of a variety of total systems available now and the open-ended capabilities to meet your future needs. Inside is a functional schematic of the 4470 master module. Each system data sheet has a corresponding schematic of the circuitry on its mode card and the transducer it was designed to accommodate. Match the module with any card and a system schematic results, showing power supply operation, calibration circuitry and customizing possibilities.

The master module of this system (identified as 4470.XXX) consists of three basic sections; a highly regulated instrument power supply, calibration circuitry (including the optional remote calibrate relays if used) and passive conditioning circuitry and components.

DEVCO PRODUCT DATA



4470/4471.1

VOLTAGE REGULATED RESISTANCE BRIDGE SIGNAL CONDITIONER

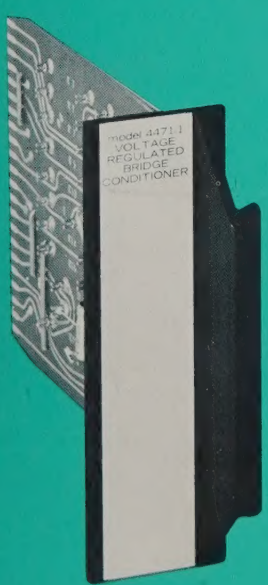
For 1, 2 or 4 Active Elements

For 2 to 10 Wire Systems

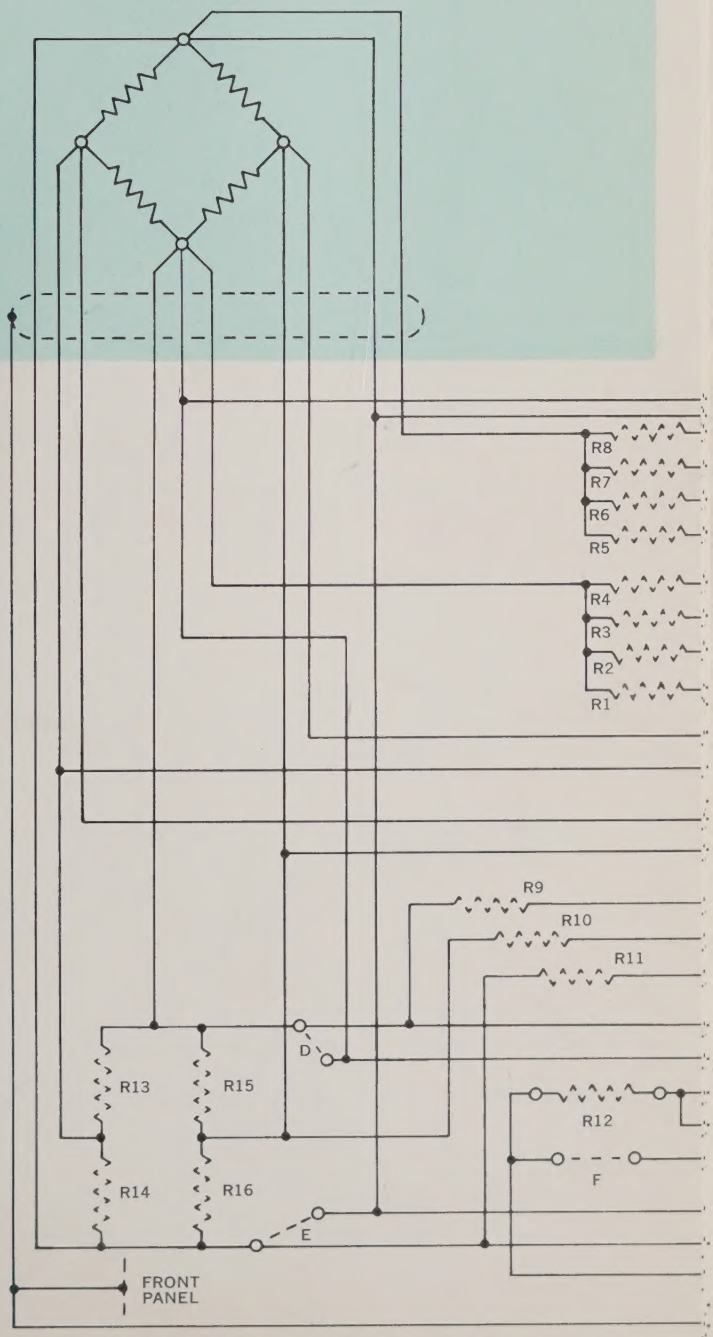
Single or Double Shunt Calibration or Series Calibration

Excitation adjustable 1 to 30 VDC or Resistance Programmable

Shown at the right is a functional schematic of the 4471.1 Mode Card and a typical transducer. When this sheet is matched with the schematic in the 4470 Brochure, a complete functional schematic of the 4470/4471.1 Signal Conditioner results; showing transducer connections, power supply operation, calibration circuitry and customizing possibilities.



Strain Gages —
Strain Gage Pressure Transducers
Load Cells, etc.



DESCRIPTION:

The Model 4471.1 Plug-in Mode Card is a voltage regulated bridge conditioner designed for use with the Model 4470 Signal Conditioner Module. It is intended to condition a wide variety of transducers with active resistive elements connected in a bridge configuration.

Circuitry on the card provides for operation of the Model 4470 Power Supply in the voltage regulated mode. Bifurcated solder terminals permit easy installation of bridge completion, bridge balancing, calibration, and excitation programming resistors. Bifurcated terminal pairs are also provided for internally connecting the power supply sensing leads and for internally connecting the calibration leads.

A transducer identification strip is provided on the handle of each mode card with space for entering transducer type, serial number, sensitivity and other pertinent data for custom matching of mode card and transducer. When the customizing possibilities of this card are fully utilized, simple insertion of the card makes all the decisions necessary to: set excitation to correct value to obtain normalized full scale output; obtain zero null output; make cal steps represent percent of full scale explicitly. The cost of a mode card is returned many times in labor savings and avoidance of mistakes.

SPECIFICATIONS FOR 4470 with 4471.1 MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS	
Transducers	1, 2, or 4-active arm resistive elements connected in a bridge configuration.
Wires	The card may be used with 2 to 10 wire systems.
Transducer Impedance	Limited only by rating of power supply, 100 mA dc, maximum, at 1 to 30 V dc.
OUTPUT CHARACTERISTICS	Same as transducer output, no active elements on Mode Card.
CONTROLS (on mode card)	None.
TRANSFER CHARACTERISTICS	
Balance Limiting (Resistors R9, R10, R11)	Terminals are provided for installation of balance limiting resistors.
Resistance Programming (Resistor R12 and Link F)	Terminals are provided for installation of a 3200 Ω/V resistor for fixed output excitation level. Link F is removed when resistor R12 is installed.
TRANSFER CHARACTERISTICS continued	
Bridge Completion (Resistors R13 through R16)	Four pairs of terminals are provided for installation of bridge completion resistors.
External Sensing (Links D and E)	Circuit normally connected for internal sensing. When sense leads are connected to external load, remove Links D and E.
CALIBRATION	
Internal (Resistors R1 through R8)	Terminals are provided for installation of up to eight resistors to provide four step bipolar double shunt calibration. Series calibration can be performed.
External	Terminals are provided for Links A, B, and C which internally connect the calibration leads if separate calibration wires are not desired.

PHYSICAL

MODE CARD	Designed for plugging into front panel of Model 4470 Module.
RESISTORS	Terminals are spaced to accept axial lead resistors having maximum envelope dimensions of 1/4" diameter by 13/16" long.
WEIGHT	100 grams (3.5 oz.) maximum, without resistors.

RELIABILITY:

Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures, together with conservative specifications, have made the name Endevco synonymous with reliability.

PRICE: (F.O.B. Pasadena) Model 4471.1 — $20.00 each

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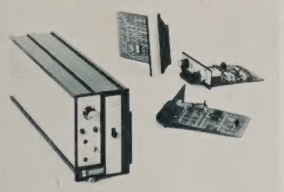


4470/4471.2

CURRENT REGULATED RESISTANCE BRIDGE SIGNAL CONDITIONER

Excitation Adjustable 0.5 to 50 mA dc

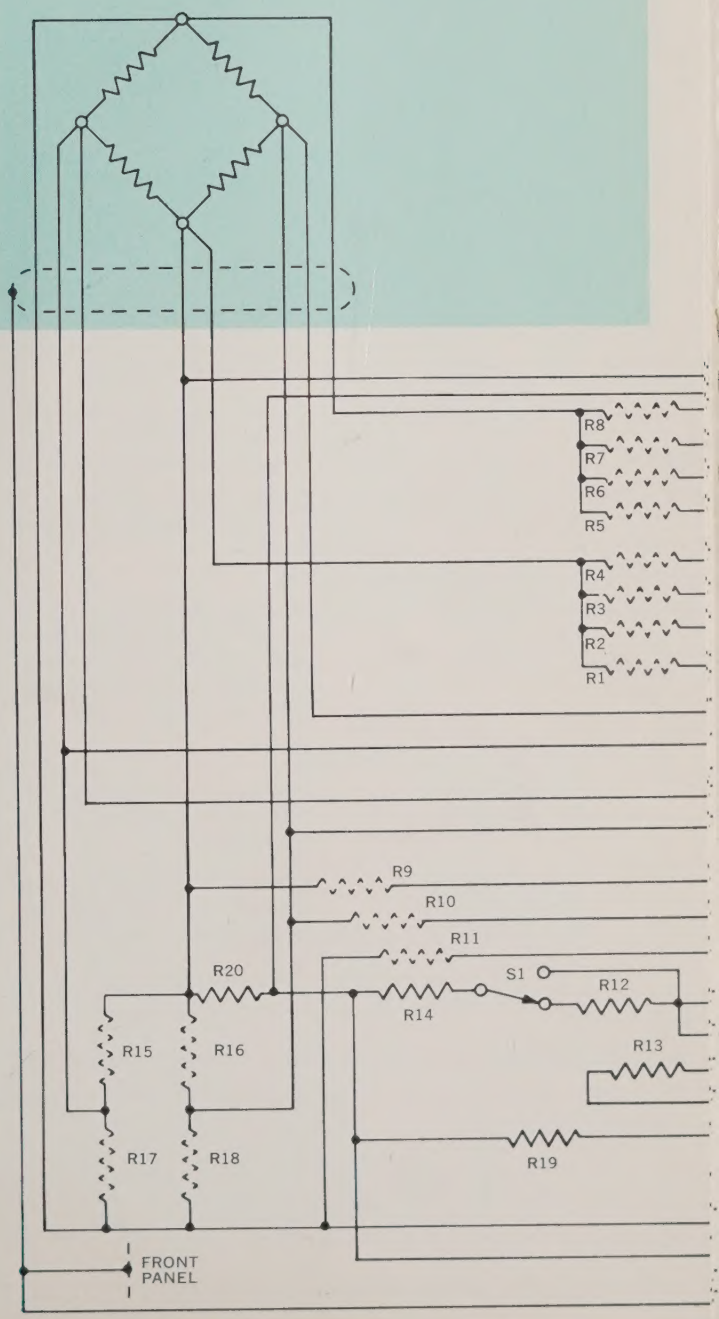
For 1, 2, or 4 Element Bridges

For 2 to 8 Wire Systems

Terminals provided for bridge completion, bridge balancing, and calibration resistors.

Shown at the right is a functional schematic of the 4471.2 Mode Card and a typical transducer. When this sheet is matched with the schematic in the 4470 Brochure, a complete functional schematic of the 4470/4471.2 Signal Conditioner results: showing transducer connections, power supply operation, calibration circuitry and customizing possibilities.

Strain Gages —
Strain Gage Pressure Transducers
Load Cells, etc.



DESCRIPTION:

The Model 4471.2 Plug-in Mode Card is a current regulated bridge conditioner designed for use with the Model 4470 Signal Conditioner Module. It is intended to condition a wide variety of transducers with active resistive elements connected in a bridge configuration.

Circuitry on the card provides for operation of the Model 4470 power supply in the current regulated mode. Bifurcated solder terminals permit easy installation of bridge completion, bridge balancing, and calibration resistors.

A transducer identification strip is provided on the handle of each mode card with space for entering transducer type, serial number, sensitivity and other pertinent data for custom matching of mode card and transducer. When the customizing possibilities of this card are fully utilized, simple insertion of the card makes all the decisions necessary to: obtain zero null output; make cal steps represent percent of full scale explicitly. The cost of a mode card is returned many times in labor savings and avoidance of mistakes.

SPECIFICATIONS FOR 4470 with 4471.2 MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS	
Transducers	1, 2, or 4 arm resistive elements connected in a bridge configuration.
Wires	The card may be used with 2 to 8 wire systems.
Transducer Impedance	Limited only by rating of power supply, 25 V dc, maximum, at 0.5 to 50 mA dc.
OUTPUT CHARACTERISTICS	Same as transducer output; no active elements on Mode Card.
CONTROLS (on Mode Card)	
Current Range (Switch S1)	Two position slide switch connects resistors R12 and R14 for 0.5 to 5 mA range; connects resistor R14 for 5 to 50 mA range.
TRANSFER CHARACTERISTICS	
Balance Limiting (Resistors R9, R10, R11)	Terminals are provided for installation of balance limiting resistors.
Bridge Completion (Resistors R15 through R18)	Four pairs of terminals are provided for installation of bridge completion resistors.
TRANSFER CHARACTERISTICS continued	
Current Control (Resistors R13, R19)	Resistor R13 sets the full scale current range. Resistor R19 limits the minimum output current.
CALIBRATION	
(Resistors R1 through R8)	Terminals are provided for installation of up to eight resistors to provide four step bipolar double shunt calibration.
Internal Connections	Terminals are provided for Links A, B, and C which internally connect the calibration leads if separate calibration wires are not desired.
Current Monitoring (Resistor R20)	Excitation current is monitored by voltage drop across R20, connected in plus excitation line (100 μA/mV).

PHYSICAL

MODE CARD	Designed for plugging into front panel of Model 4470 Module.
RESISTORS	Terminals are spaced to accept axial lead resistors having maximum envelope dimensions of ¼" diameter by 13/16" long.
WEIGHT	110 grams (4 oz.) maximum, without optional resistors.

Continued product improvement necessitates that Endevco reserve the right to change these specifications and/or prices without notice.

RELIABILITY: Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures together with conservative specifications, have made the name Endevco synonymous with reliability.

PRICES: (F.O.B. Pasadena) Model 4471.2 — $35.00 each

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ENDEVCO PRODUCT DATA

4470/4471.3

POTENTIOMETER SIGNAL CONDITIONER

For 3 Wire Potentiometer Transducers

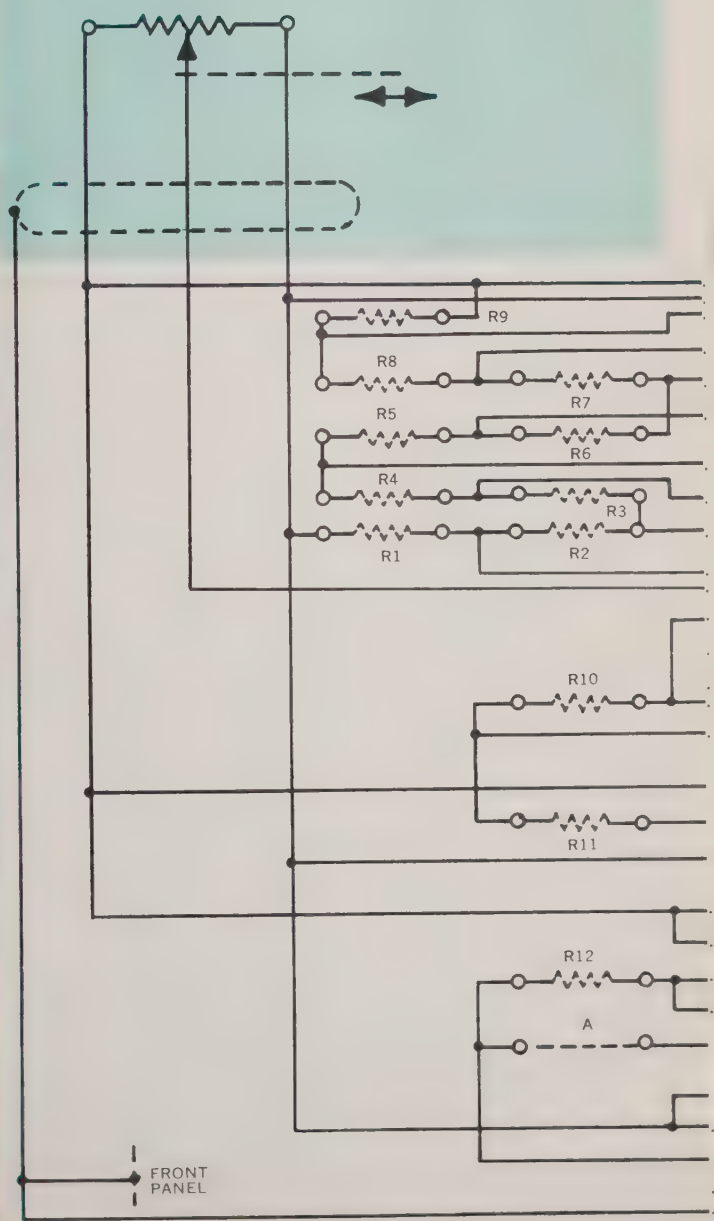
Resistance Substitution Calibration

Eight Calibration Steps

Excitation Adjustable
1 to 30 V dc or
Resistance Programmable

Shown at the right is a functional schematic of the 4471.3 Mode Card and a typical transducer. When this sheet is matched with the schematic in the 4470 Brochure, a complete functional schematic of the 4470/4471.3 Signal Conditioner results, showing transducer connections, power supply operation, calibration circuitry and customizing possibilities.

Potentiometer Transducers



DESCRIPTION:

The Model 4471.3 Plug-in Mode Card is a potentiometer transducer conditioner designed for use with the Model 4470 Signal Conditioner Module. It is intended for use with three wire potentiometer type transducers connected in a bridge configuration, with the balance potentiometer in the 4470 forming the bridge completion arms.

Circuitry on the card provides for operation of the Model 4470 power supply in the voltage regulated mode. Excitation is continuously adjustable or fixed by means of a programming resistor. Bifurcated solder terminals are provided for easy installation of calibration, voltage programming, and output attenuation resistors.

Calibration mode of operation is resistance substitution. During calibration the transducer is replaced as the signal source by the calibration resistor string but remains connected to the excitation source to avoid transients and maintain a constant load. Up to eight calibration steps may be employed.

Resistors R10 and R11 form an L-pad to standardize output and minimize circuit nonlinearity due to output loading.

A transducer identification strip is provided on the handle of each mode card with space for entering transducer type, serial number, sensitivity and pertinent data for custom matching of mode card and transducer. When the customizing possibilities of this card are fully utilized, simple insertion of the card makes all the decisions necessary to: set the selected excitation, establish preselected calibration steps over the range of operation, set the output impedance, and set full scale output. The cost of the card is returned many times in labor savings and avoidance of mistakes.

SPECIFICATIONS FOR 4470 with 4471.3 MODE CARD

(Also see Specifications for 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS	
Transducers	Potentiometer type transducers.
Transducer Current	100 mA dc maximum
Wires	3-wire system
Excitation Voltage	1 to 30 Volts dc
OUTPUT CHARACTERISTICS	
Output Voltage	Transducer output or less, no active elements on mode card.
Full Scale Output (Resistors R10 and R11)	Terminals are provided for installation of L-Pad to attenuate output voltage. If R11 is not required, it must be jumped to complete the circuit.
OUTPUT CHARACTERISTICS continued	
Output Impedance	Selectable by choice of R10, R11 and transducer.
CONTROLS (on Mode Card)	None
TRANSFER CHARACTERISTICS	
Resistance Programming (Resistor R12 and Link A)	Terminals are provided for installation of a 3200 Ω/V resistor for fixed output excitation level. Link A is removed when resistor R12 is installed.
Bridge Completion	Balance potentiometer, R28, 20,000 Ohms, in 4470 Module forms bridge completion arms.
CALIBRATION (Resistors R1 through R9)	Terminals are provided for installation of up to 9 calibration resistors.

PHYSICAL

MODE CARD	Designed for plugging into front panel of 4470 Module.
RESISTORS	Terminals are spaced to accept axial lead resistors having maximum envelope dimensions of 1/4″ diameter by 13/16″ long.
WEIGHT	100 grams (3.5 oz.) maximum, without resistors.

Continued product improvement necessitates that Endevco reserve the right to change these specifications and/or prices without notice.

RELIABILITY: Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures together with conservative specifications, have made the name Endevco synonymous with reliability.

PRICE: (F.O.B. Pasadena) Model 4471.3 — $25.00 each

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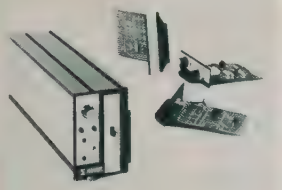


4470/4472.1

AccuMode®
SIGNAL CONDITIONER

For Single Element Variable Resistance Sensors

Maintains Constant Current through Transducer

Linear Output with Large Changes in Transducer Resistance

Eight Calibration Steps, Up and Down Scale

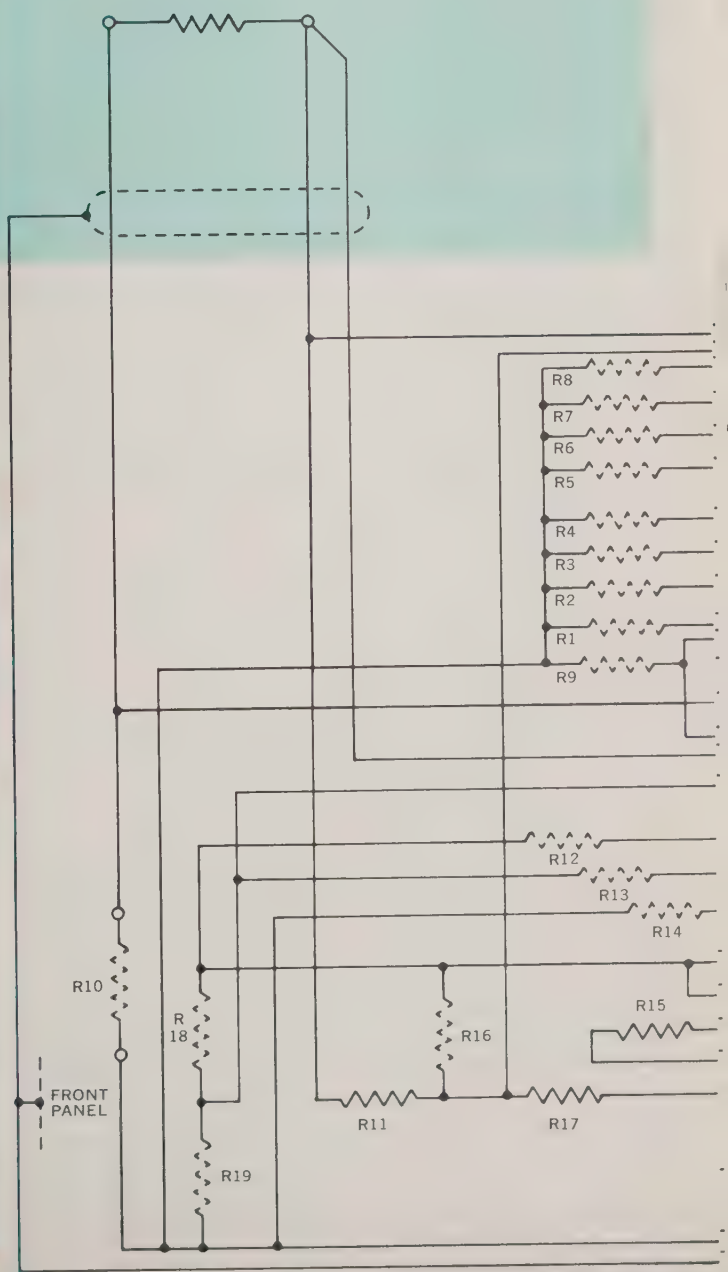
Bridge Completion and Balancing Circuitry Provided

Shown at the right is a functional schematic of the 4472.1 Mode Card and a typical transducer. When this sheet is matched with the schematic in the 4470 Brochure, a complete functional schematic of the 4470/4472.1 Signal Conditioner results, showing transducer connections, power supply operation, calibration circuitry and customizing possibilities.

Single Arm Variable Resistance Transducers

Strain Gages

Resistance Temperature Sensors



DESCRIPTION:

The Model 4472.1 Plug-in Mode Card is a current regulated conditioner designed for use with the Model 4470 Signal Conditioner Module. It is intended for use with single element resistance sensors. Circuitry on the card provides for operation of the Model 4470 power supply in the current regulated mode.

The unique AccuMode® circuit maintains constant excitation current through the transducer resistance element. Thus, the output voltage is an explicitly linear function of the change of resistance. The circuit induced nonlinearity which results from large resistance changes in a single arm transducer connected in a bridge circuit is avoided.

Bifurcated solder terminals are provided for the easy installation of balance limiting, bridge completion, sensing arm, and calibration resistors. The current sensing resistor, R16, and current monitoring resistor, R11, form one arm of the bridge circuit. R18 and R19 form two other arms. The transducer resistance, in series with R10, completes the bridge.

By maintaining the voltage drop across R16 constant, the current through the active element is maintained constant. Voltage across this current sensing resistor is adjustable from <0.5 to >5.0 V dc by means of the "excit" potentiometer on the Model 4470.

Calibration mode of operation is insertion of resistance in series with the active element. Parallel combination of R9 and R10 remains in series with the transducer during operation. During calibration, the selection of R1 through R8 in place of R9 allows addition or subtraction of resistance in the active arm of bridge.

A transducer identification strip is provided on the handle of each mode card with space for entering transducer type, serial number, sensitivity and other pertinent data for custom matching of mode card and transducer. When the customizing possibilities of this card is fully utilized, simple insertion of the card makes all the decisions necessary to: complete the bridge circuit, set the constant excitation current through the transducer, and establish preselected calibration steps over the range of operation. The cost of the card is returned many times in labor savings and avoidance of mistakes.

SPECIFICATIONS FOR 4470 with 4472.1 MODE CARD

(Also see Specifications for 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS	
Transducers	Single arm active resistance elements
Wires	3 wire system.
Transducer Current	0.5 to 50 mA dc.
Bridge Voltage	25 V dc, maximum.
OUTPUT CHARACTERISTICS	
Output Voltage	Actual bridge output. No active elements on mode card.
CONTROLS (on mode card)	None
TRANSFER CHARACTERISTICS	
Balance Limiting (Resistors R12, R13, R14)	Terminals are provided for installation of balance resistors.
TRANSFER CHARACTERISTICS continued	
Current Control (Resistors R15, R16, R17)	R15 sets the full scale current range. Terminals are provided for R16, the power supply current sensing resistor connected in the bridge in series with R11. R16 is limited to range of 10 to 10,000 ohms. R17 limits the minimum output current.
Bridge Completion (Resistors R18, R19)	Terminals are provided for installation of bridge completion resistors. Current through these resistors must be limited to 50 mA or less.
Current Monitoring (Resistor R11)	Voltage across 10 ohm $\pm 1\%$ resistor is proportional to current through active arm, 100 μA/mV.
CALIBRATION (Resistors R1 through R10)	Terminals are provided for installation of 10 calibration resistors.

PHYSICAL

MODE CARD	Designed for plugging into front panel of 4470 Module.
RESISTORS	Terminals are spaced to accept axial lead resistors having maximum envelope dimensions of ¼" diameter by 13/16" long.
WEIGHT	100 grams (3.5 oz.) maximum, without optional resistors.

Continued product improvement necessitates that Endevco Corporation reserve the right to change specifications without notice.

RELIABILITY: Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures, together with conservative specifications, have made the name Endevco synonymous with reliability.

PRICE: (F.O.B. Pasadena) Model 4472.1 — $30.00 each.

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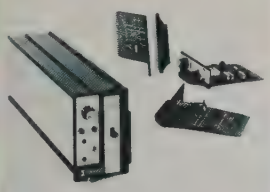


4470/4473.1

RESISTANCE TEMPERATURE BULB SIGNAL CONDITIONER

Voltage Insertion Calibration

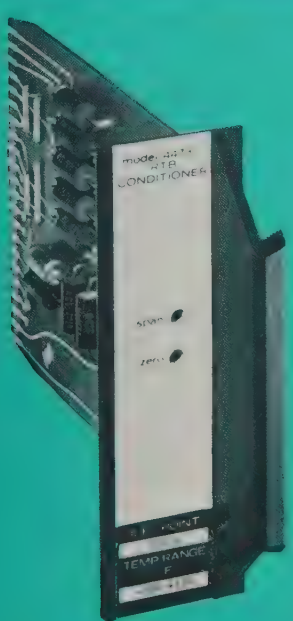
For 4 Wire, Single Active Arm, Platinum Temperature Sensors

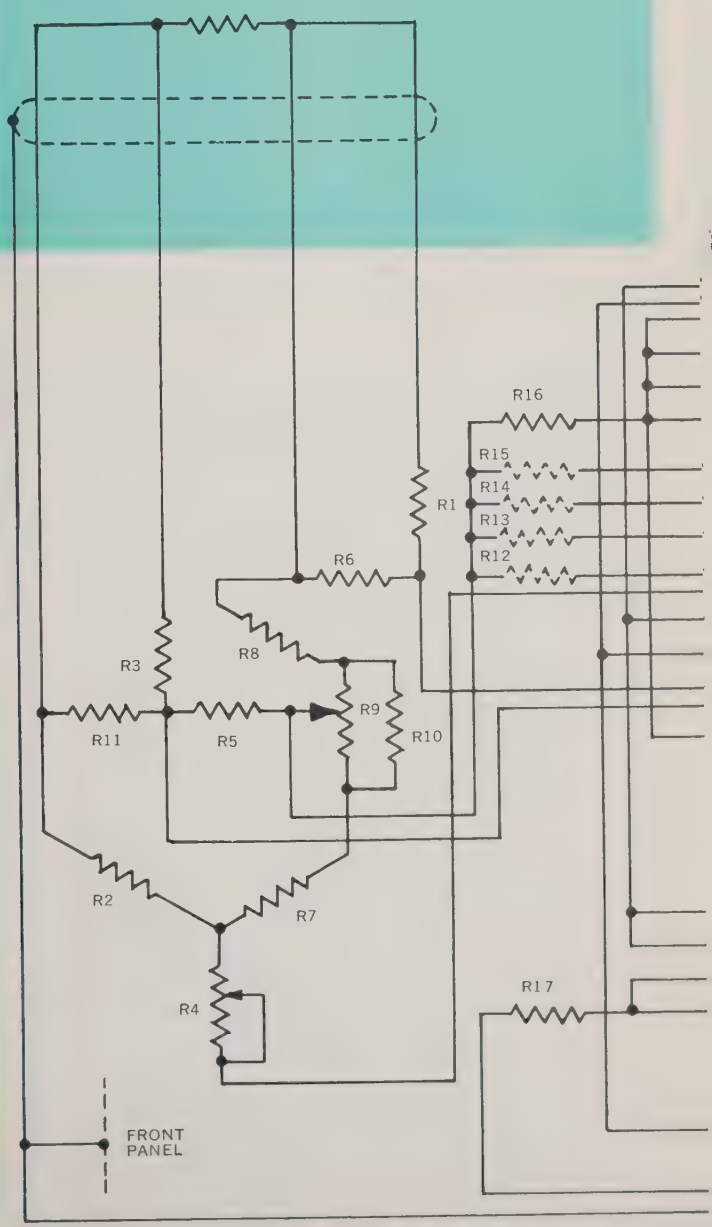
Standardized Output, 10 mV Full Scale

Wide Selection of Temperature Ranges and Ice Points

Platinum Temperature Bulbs

Shown at the right is a functional schematic of the 4473.1 Mode Card and a typical transducer. When this sheet is matched with the schematic in the 4470 Brochure, a complete functional schematic of the 4470/4473.1 Signal Conditioner results, showing transducer connections, power supply operation, calibration circuitry, and output controls.





DESCRIPTION:

The Model 4473.1 Plug-in Mode Card is a resistance temperature bulb conditioner designed for use with the Model 4470 Signal Conditioner Module. It is intended for use with four wire, single active arm, platinum temperature sensors. Circuitry on the card provides for operation of the Model 4470 power supply in the voltage regulated mode.

The card provides bias voltage for zeroing the resistance bulb output, circuitry for voltage insertion calibration and a span adjust potentiometer to adjust accurately the full scale output. All resistors, necessary to complete a full double bridge circuit for a given ice point resistance and temperature range are installed. During calibration the power supply excitation voltage is removed from the bridge and placed across the selected calibration resistor and series output resistor.

Each card is identified with the temperature range and ice point resistance for which it is designed. See attached Reference Chart relating dash numbers with temperature range and ice point resistance. The Model 4473.2 Mode Card is similar to this card except that the 4473.2 employs resistance substitution calibration.

Transducer identification strips are provided on the handle of each mode card with space for entering transducer type, serial number, and other pertinent data for custom matching of mode card and transducer. Simple insertion of the card makes all the decisions necessary to: program power supply for proper bridge excitation, set full scale output, and fix the calibrated output for specific temperatures. The cost of the card is returned many times in labor savings and avoidance of mistakes.

SPECIFICATIONS FOR 4470 and 4473.1 MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS

Transducers	Single active arm, platinum temperature sensors.
Wires	4-wire system.

OUTPUT CHARACTERISTICS

Signal Output	10 mV full scale for change of input resistance corresponding to designed temperature range and ice point resistance.
Output Impedance	1000 Ohms, maximum.

CONTROLS (On mode card)

Span (Potentiometer R4)	15 turn potentiometer for accurately adjusting full scale output. Range is ±200 μ V; resolution is 3 μ V, maximum.
Zero (Potentiometer R9)	15 turn potentiometer for adjusting output of bridge to zero. Range is ±200 μ V (see exceptions on table attached); resolution is 3 μ V, maximum.

TRANSFER CHARACTERISTICS

Linearity	±0.1% of full scale maximum deviation from a straight line between end points, when terminated into a 1 megohm load. (See exceptions on table attached).
Effect of Lead Wire Resistance	5 μ V maximum change in output voltage for lead wire resistance changes from 0 to 5 Ohms per conductor in any combination of leads.
Bridge Voltage	Set at 30 ± 0.03 V by programming resistor R17, 96 kΩ, ± 0.1%.

CALIBRATION

(Resistors R12 through R15)	Terminals are provided for installation of up to four calibration resistors to provide voltage insertion calibration.
Series Output Resistor (Resistor R16)	Calibration voltage appears across this 10 Ohm ±0.1% resistor in series with selected calibration resistor.

PHYSICAL

MODE CARD	Designed for plugging into front panel of 4470 Module.
RESISTORS	Bifurcated solder terminals are spaced to accept axial load resistors having maximum envelope dimensions of 1/4" diameter by 13/16" long.
WEIGHT	100 grams (3.6 oz.) maximum, without calibration resistors.

Continued product improvement necessitates that Endevco reserve the right to modify these specifications and/or prices without notice.

RELIABILITY:

Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures, together with conservative specifications, have made the name Endevco synonymous with reliability.

PRICE: (F.O.B. Pasadena) Model 4473.1 — $60.00 each (Specify Dash No.)

See attached table for list of available mode cards, each with a specific ice point resistance and temperature range. For an ice point resistance and temperature range not shown, there is a one time charge of $300.00.

Prices of Endevco® products to be exported or purchased with intent to export beyond the territorial limits of the United States are subject to special quotation. Your Endevco Field Engineer is qualified to advise you regarding changes in printed information.

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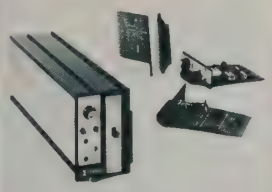


4470/4473.2

RESISTANCE TEMPERATURE BULB SIGNAL CONDITIONER

Resistance Substitution Calibration

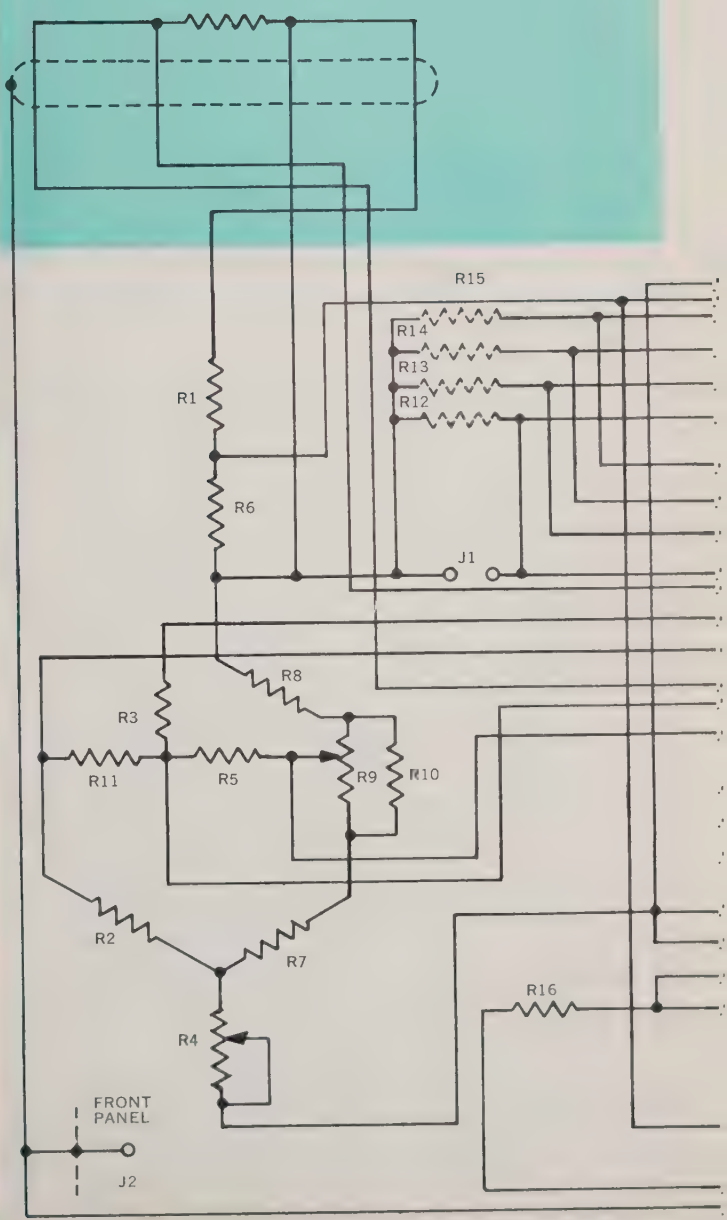
For 4 Wire, Single Active Arm, Platinum Temperature Sensors

Standardized Output, 10 mV Full Scale

Wide Selection of Temperature Ranges and Ice Points

Platinum Temperature Bulbs

Shown at the right is a functional schematic of the 4473.2 Mode Card and a typical transducer. When this sheet is matched with the schematic in the 4470 Brochure, a complete functional schematic of the 4470/4473.2 Signal Conditioner results, showing transducer connections, power supply operation, calibration circuitry, and output controls.



DESCRIPTION:

The Model 4473.2 Plug-in Mode Card is a resistance temperature bulb conditioner designed for use with the Model 4470 Signal Conditioner Module. It is intended for use with four wire, single active arm, platinum temperature sensors. Circuitry on the card provides for operation of the Model 4470 power supply in the voltage regulated mode.

The card provides bias voltage for zeroing the resistance bulb output, circuitry for resistance substitution calibration and a span adjust potentiometer to adjust accurately the full scale output. All resistors, necessary to complete a full double bridge circuit for a particular ice point resistance and temperature range are installed. During calibration the transducer is removed from the circuit and one of the selected calibration resistors installed in its place. An external decade box or resistor can be connected to front panel jacks to serve as the calibration resistor.

Each card is identified with the temperature range and ice point resistance for which it is designed. See attached Reference Chart relating dash numbers with temperature range and ice point resistance. The Model 4473.1 Mode Card is similar to this card except that the 4473.1 employs voltage insertion calibration.

Transducer identification strips are provided on the handle of each mode card with space for entering transducer type, serial number, and other pertinent data for custom matching of mode card and transducer. Simple insertion of the card makes all the decisions necessary to: program the power supply for proper bridge excitation, set full scale output, and fix the calibrated output for specific temperatures. The cost of the card is returned many times in labor savings and avoidance of mistakes.

SPECIFICATIONS FOR 4470 with 4473.2 MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS

Transducers	Single active arm, platinum temperature sensors.
Wires	4-wire system.

OUTPUT CHARACTERISTICS

Signal Output	10 mV full scale for change of input resistance corresponding to designed temperature range and ice point resistance.
Output Impedance	1000 Ohms, maximum.

CONTROLS (On mode card)

Span (Potentiometer R4)	15 turn potentiometer for accurately adjusting full scale output. Range is ±200 μV; resolution is 3 μV, maximum.
Zero (Potentiometer R9)	15 turn potentiometer for adjusting output of bridge to zero. Range is ±200 μV (see exceptions on table attached); resolution is 3 μV, maximum.

TRANSFER CHARACTERISTICS

Linearity	±0.1% of full scale maximum deviation from a straight line between end points, when terminated into a 1 megohm load. (See exceptions on table attached).
Effect of Lead Wire Resistance	5 μV maximum change in output voltage for lead wire resistance changes from 0 to 5 Ohms per conductor in any combination of leads.
Bridge Voltage	Set at 30 ±0.03 V by programming resistor R16, 96 k ohm ±0.1%.

CALIBRATION

(Resistors R12 through R15)	Terminals are provided for installation of up to four calibration resistors to provide resistance substitution calibration. An external decade box or resistor can be connected through front panel jacks into the calibration circuit in place of R12.

PHYSICAL

MODE CARD	Designed for plugging into front panel of 4470 Module.
RESISTORS	Bifurcated solder terminals are spaced to accept axial load resistors having maximum envelope dimensions of 1/4″ diameter by 13/16″ long.
WEIGHT	105 grams (3.7 oz.) maximum, without calibration resistors.

Continued product improvement necessitates that Endevco reserve the right to modify these specifications and/or prices without notice.

RELIABILITY:

Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures, together with conservative specifications, have made the name Endevco synonymous with reliability.

PRICE: (F.O.B. Pasadena) Model 4473.2 — $60.00 each (Specify Dash No.) See attached table for list of available mode cards, each with a specific ice point resistance and temperature range. For an ice point resistance and temperature range not shown, there is a one time charge of $300.00.

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REFERENCE CHART FOR

4470/4473.1
4470/4473.2

RESISTANCE TEMPERATURE BULB SIGNAL CONDITIONERS

REFERENCE CHART OF AVAILABLE MODE CARDS

The following is a list of currently available Model 4473.1 and Model 4473.2 Mode Cards. Each dash number is associated with a specific ice point (+32 F) resistance and a temperature range. If a desired ice point resistance and/or temperature range is not shown, check with the factory or your local Endevco Field Engineer or Representative. Additional mode cards may have been added since the last printing of this chart.

Linearity error is ±0.1% of full scale maximum deviation from a straight line between end points, except as noted below. All deviations are in a positive direction.

Mode cards with a zero adjustment range less than ±200 μV are listed following the reference chart.

Dash No.	Ice Point Resistance, Ohms	Temperature Range, °F	Error[1] vs. Output, in % of Full Scale				
			20%	40%	50%	60%	80%
−1	1380	−425 to −375	—	—	—	—	—
−2	1380	−425 to −410	—	—	—	—	—
−3	1380	−425 to +100	.78	1.16	1.20	1.14	.76
−4	1380	−300 to −250	—	—	—	—	—
−5	1380	−350 to +100	.74	1.11	1.15	1.10	.72
−6	1380	−325 to −275	—	—	—	—	—
−7	1380	−200 to +650	.97	1.44	1.49	1.43	.94
−8	50	0 to +1200	—	—	—	—	—
−9	1380	0 to +1200	1.40	2.07	2.14	2.03	1.33
−10	50	0 to +1800	—	—	—	—	—
−11	1380	0 to +1800	1.58	2.32	2.40	2.28	1.49
−12	1380	−100 to +300	.67	1.00	1.04	1.00	.65
−13	1380	−305 to −280	—	—	—	—	—
−14	2495	−65 to +300	.87	1.30	1.34	1.28	.84
−15	1256	−305 to −280	—	—	—	—	—
−16	1256	−425 to −325	—	—	—	—	—
−17	1256	−425 to −410	—	—	—	—	—
−18	1256	−200 to +300	.72	1.08	1.11	1.07	.70
−19	200	−300 to +200	—	—	—	—	—
−20	1256	−350 to +100	.70	1.04	1.08	1.03	.68
−21	1256	−425 to +100	.74	1.11	1.15	1.10	.75
−22	100	−100 to +300	—	—	—	—	—
−23	100	−300 to −100	—	—	—	—	—
−24	100	−425 to −200	—	—	—	—	—
−25	1256	−425 to −395	—	—	—	—	—
−26	1256	−425 to −375	—	—	—	—	—
−27	1256	−300 to −280	—	—	—	—	—
−28	1256	−300 to −250	—	—	—	—	—
−29	1256	−300 to −100	.47	.70	.73	.70	.46
−30	1256	−300 to +100	.65	.96	1.00	.95	.62

NOTES [1] Deviation from a straight line through the end points. All deviations are in a positive direction.

Dash No.	Ice Point Resistance, Ohms	Temperature Range, °F	Error[1] vs. Output, in % of Full Scale 20%	40%	50%	60%	80%
−31	1256	−300 to +500	.90	1.34	1.38	1.32	.87
−32	1256	−200 to +500	.83	1.24	1.28	1.22	.81
−33	100	−425 to −100	—				
−34	100	−425 to +100					—
−35	100	−350 to −200	—	—			
−36	100	−350 to +100	—				—
−37	100	−300 to 0	—				—
−38	100	−300 to +100	—			—	
−39	100	−200 to +100	—				
−40	100	−200 to +350	—			—	—
−41							
−42	100	−100 to +150	—		—	—	—
−43	100	−50 to +600	—	—	—	—	
−44	100	0 to +150	—				
−45	100	0 to +300					
−46	100	−300 to +200	—				—
−47	100	0 to +200					
−48	2500	−297 to −270	—			—	—
−49	425	−200 to +500	.49	.74	.76	.73	.48
−50	1256	−425 to −400					
−51	1256	−350 to −200	.41	.61	.64	.61	.40
−52	1256	+50 to +160	.33	.49	.51	.49	.32
−53	1380	−425 to −200	.49	.73	.75	.72	.48
−54	1380	−300 to −280	—				
−55	1380	−300 to 0	.58	.87	.90	.86	.57
−56	1380	0 to +150	.40	.60	.62	.58	.39
−57	1380	0 to +200	.46	.69	.71	.68	.45
−58	1380	+50 to +160	.37	.55	.57	.55	.36
−59	100	−300 to +300	—				—
−60	100	−300 to −285	—				—
−61	100	−200 to +300	—		—	—	
−62	425	−200 to +300	.42	.63	.65	.62	.41

NOTES [1] Deviation from a straight line through the end points. All deviations are in a positive direction.

Zero Adjustment Range is ±200 μV for all cards except: −3, −21 & −33: +40 to −200 μV
−24 & −53: +80 to −200 μV
−34: +20 to −200 μV

Continued product improvement necessitates that Endevco reserve the right to modify these specifications and/or prices without notice.

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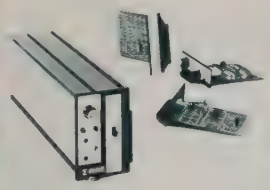


4470/4474.1

THERMOCOUPLE SIGNAL CONDITIONER

Plug-in Mode Card adapts to wide range of thermocouples and other millivolt sources

Bias Voltage Adjustable ±9.5 mV to Set Zero Output

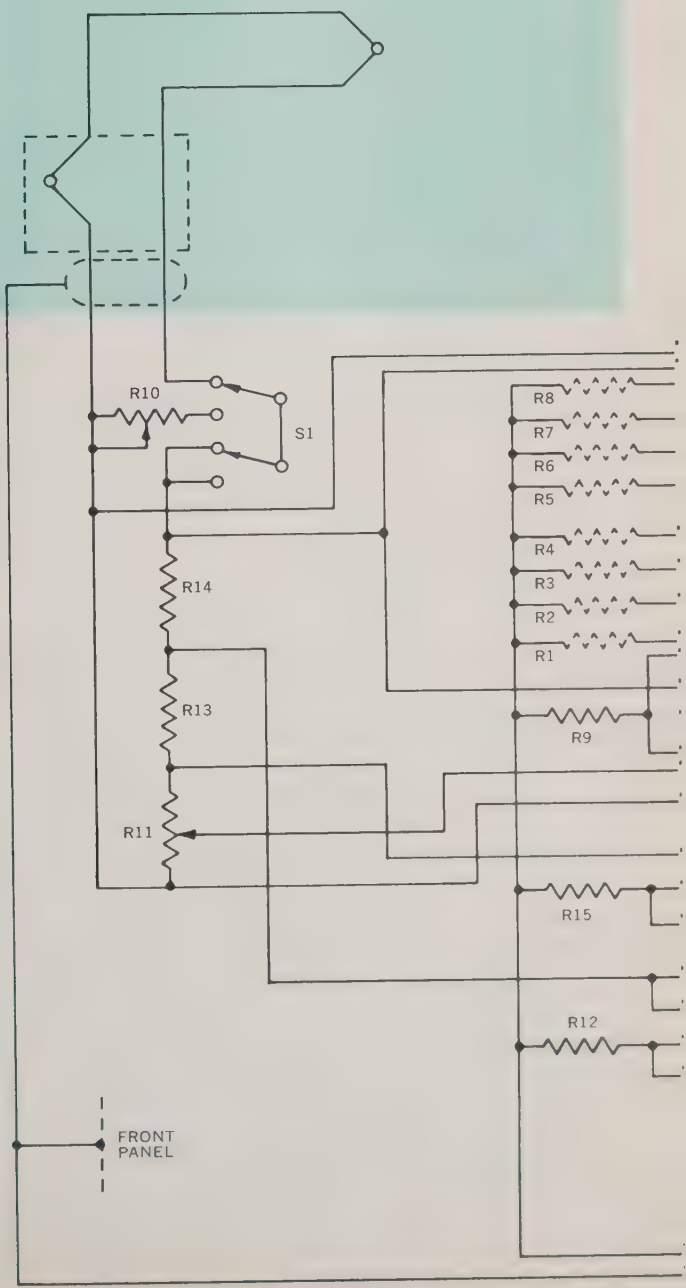
Up to 8 steps of Voltage Insertion Calibration

Span Adjustable for Selection of Full Scale

Shown at the right is a functional schematic of the 4474.1 Mode Card and a typical transducer. When this sheet is matched with the schematic in the 4470 Brochure, a complete functional schematic of the 4470/4474.1 Signal Conditioner results, showing transducer connections, calibration and zeroing circuitry, power supply operation and customizing possibilities.

Thermocouples

Millivolt Sources



DESCRIPTION:

The Model 4474.1 Plug-in Mode Card is a thermocouple conditioner designed for use with the Model 4470 Signal Conditioner Module. It is intended to condition a variety of thermocouples over their rated range of operation, or other simple sources of millivolt level signals.

The card provides bias voltage for zeroing the thermocouple output, circuitry for voltage insertion calibration, and a span adjust potentiometer to control full scale output. Calibration may be performed with the thermocouple in the circuit or removed and replaced by a line resistance simulation potentiometer. A programming resistor fixes the output voltage of the Model 4470.

A transducer identification strip is provided on the handle of each mode card with space for entering transducer type, serial number, range, and other pertinent data for custom matching of mode card and transducer. When the customizing possibilities of this card are fully utilized, simple insertion of the card makes all the decisions necessary to obtain bias voltage, set full scale output, and fix the calibrated output for specific temperatures. The cost of the card is returned many times in labor savings and avoidance of mistakes.

SPECIFICATIONS FOR 4470 with 4474.1 MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS	
Transducers	Self-generating thermocouples or other low impedance millivolt sources.
Source Impedance	100 Ω, maximum
OUTPUT CHARACTERISTICS	
Output Impedance	0 to 1000 ohms depending on setting of span control.
Output Voltage	Transducer output or less, no active elements on Mode Card.
CONTROLS (on Mode Card)	
Zero (Switch S1)	Pushbutton switch opens thermocouple connection and inserts line substitution potentiometer, R10.
Line Resistor (Potentiometer R10)	100 ohm line substitution potentiometer, screwdriver adjustable.
Span (Potentiometer R11)	1000 ohm trimming potentiometer, screwdriver adjustable, used to set desired full scale output.
TRANSFER CHARACTERISTICS	
Bias Adjust (Resistors R9, R12 through R15)	Adjustable ±9.5 mV by means of ten turn 20 K ohm balance potentiometer, R28, in 4470. Programming resistor, R12, 96 K ohm, sets output of 4470 power supply to 30 V dc. Bias is developed across 10 ohm resistors, R13 and R14, and limited by R15. Resistor, R9, completes bias bridge circuit.
Span Adjust (Resistor R11)	Transducer output appears across 1000 ohm potentiometer and may be attenuated to set full scale output signal.
CALIBRATION	
(Resistors R1 through R8)	Terminals are provided for installation of up to eight calibration resistors. During calibration these resistors replace R9. Actuating zero switch, S1, removes thermocouple from circuit and substitutes line substitution potentiometer, R10.

PHYSICAL

MODE CARD	Designed for plugging into front panel of Model 4470 Module.
RESISTORS	Bifurcated solder terminals are spaced to accept axial lead resistors having maximum envelope dimensions of ¼″ diameter by 13/16″ long.
WEIGHT	105 grams (3.7 oz.), maximum, without calibration resistors.

Continued product improvement necessitates that Endevco reserve the right to modify these specifications and/or prices without notice.

RELIABILITY: Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures, together with conservative specifications, have made the name Endevco synonymous with reliability.

PRICE: (F.O.B. Pasadena) Model 4474.1 — $50.00 each

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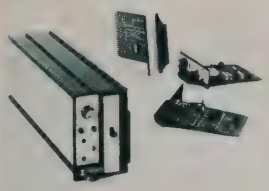


4475.1

DESIGNERS CARD

You provide the transducer interface, the 4470 provides:

A highly isolated, highly regulated power source

A well shielded enclosure

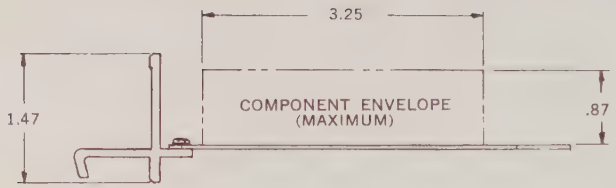
A convenient packaging system

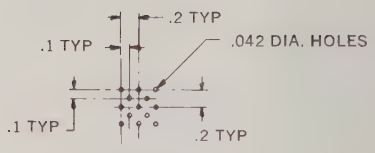
Calibration and monitoring circuitry

Routing of data outputs through normal data systems connections.

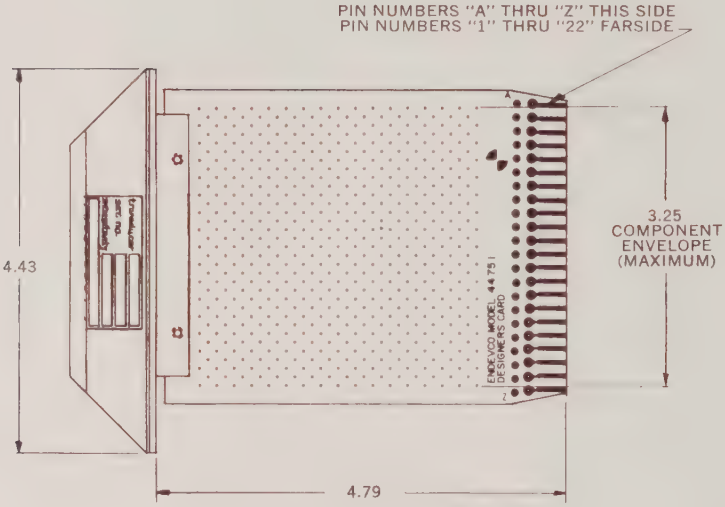
Match this Data Sheet with the schematic in the 4470 Brochure and sketch in your own transducer conditioning circuitry. The result is a unique solution to your conditioning problem. Refer to Data Sheets in the standard series for power supply connections in either a constant voltage or constant current mode.

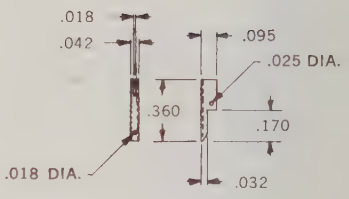
Virtually
any
Transducer





TYPICAL
HOLE PATTERN





PIN DETAIL
(VECTOR #T42-1)

Dimensions in inches

TOLERANCES
.XX = ±.03
.XXX = ±.010

DESCRIPTION:

The Model 4475.1 Plug-in Mode Card is designed for prototyping or "one shot" custom design of conditioning circuitry not provided in the standard series. All 44 access points to the master module are made available at the gold-plated contacts on the connector edge of the card. The circuit board is perforated overall on a standard 0.1-inch spacing for direct insertion of components or for insertion of the Vector #T 42-1 pins (100 furnished with card).

The power supply of the 4470 can be operated in either a constant voltage or a constant current mode by making the appropriate circuit connections on the mode card. Output may be continuously adjustable by means of the master module excitation adjust, or fixed by means of an excitation programming resistor.

The front panel of the 4475.1 can be drilled for installation of controls or connectors (so long as the maximum component envelope is not exceeded) and electrical access to the transducer can be either front panel or through the normal rack connectors. Thus virtually any transducer can be accommodated, and all circuitry enjoys the ideal environment of a very well shielded and isolated enclosure.

A transducer identification strip is provided on the mode card handle with space for entering transducer type, serial number, sensitivity, and other pertinent data.

PRICE: (F.O.B. Pasadena) Model 4475.1 — $30.00 each

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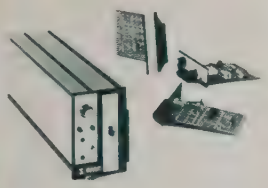


4470/4476.1

PIEZORESISTIVE ACCELEROMETER SIGNAL CONDITIONER

(Voltage Regulated, With Gain)

Differential Input

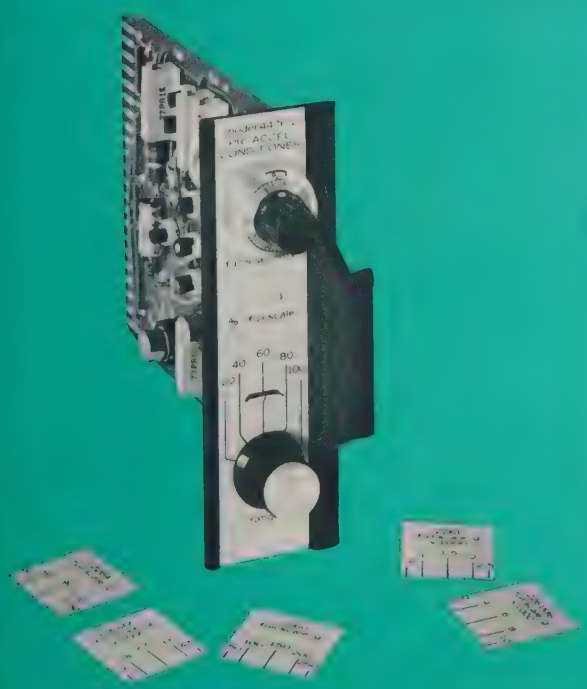
Standardized, Full Scale Output of ±2.5 Volts

Full Scale Output for 20%, 40%, 60%, 80%, or 100% of Accelerometer Range

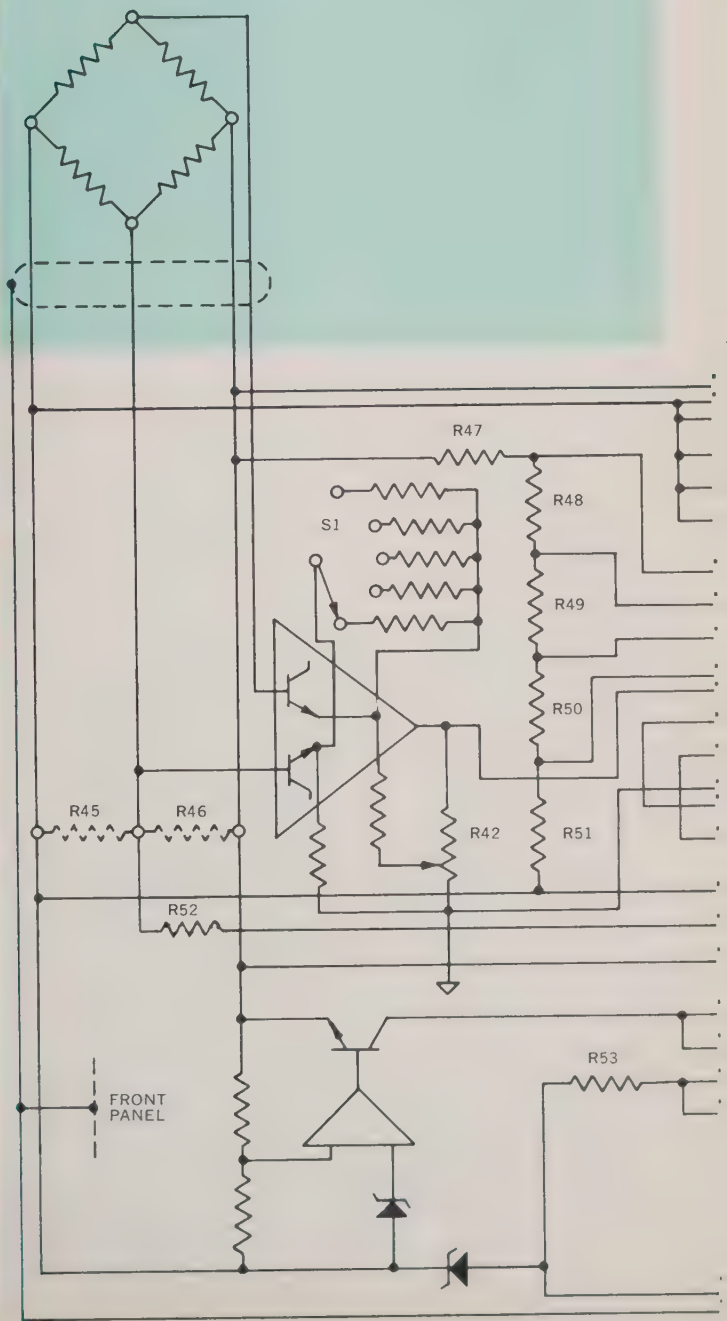
For 2 or 4 Arm Piezoresistive Accelerometers

For Piezoresistive Accelerometers with Full Range Output of 175 to 675 mV

Shown at the right is a functional schematic of the 4476.1 Mode Card and a typical transducer. When this sheet is matched with the schematic in the 4470 Brochure, a complete functional schematic of the 4470/4476.1 Signal Conditioner results, showing transducer connections, power supply operation, calibration circuitry and customizing possibilities.



2260 Series Accelerometers



DESCRIPTION:

The Model 4476.1 Plug-in Mode Card is a Piezoresistive Accelerometer Conditioner designed for use with the Model 4470 Signal Conditioner Module. It is intended to condition piezoresistive accelerometers, connected in a bridge configuration, with a full range output of 175 to 675 mV, and requiring amplification.

Circuitry on the card provides for dialing in the full range output of the transducer, and amplification of signal to obtain a standardized full scale output of 2.5 Volts. Transducer excitation voltage, bridge balancing, and voltage substitution calibration is also provided. Bifurcated solder terminals permit easy installation of bridge completion resistors.

A transducer identification strip is provided on the handle of each mode card with space for entering transducer type, serial number, sensitivity, and other pertinent data for custom matching of mode card and transducer. A replaceable range identification label is supplied with each 2260 Series Accelerometer shipped by Endevco. When inserted in the 4476.1 Front Panel, the range switch is converted to read directly in full scale g's.

SPECIFICATIONS FOR 4470 with 4476.1 MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS	
Transducers	2 or 4 active arm resistive elements connected in a bridge configuration.
Input Connection	Differential
Input Impedance	1 megohm, minimum
Source Resistance	1000 Ohms, maximum
Overload Recovery Time	50 microseconds
OUTPUT CHARACTERISTICS	
Output Connection	Single ended
Output Voltage	
Full Scale	±2.5 Volts pk
Overvoltage	±7.5 Volts pk, nominal
Linear Output Current	±2.5 mA pk, maximum
Output Impedance	Less than 5 Ohms
Noise and Ripple	2 mV rms, maximum
Capacitive Load Effect	Stable to 10 μF
Zero Stability and Temperature Coefficient	0.2% of F.S. for 24 hours plus 0.02%/°F.
POST REGULATOR (Excitation)	
Output Voltage	Adjustable 9.5 to 10.5 V dc. Factory set at 10 ±0.02 V dc with 500 Ohm load.
Output Current	0 to 50 mA dc
Short Circuit Protection	Circuit will not be damaged due to short circuit at output.
Line and Load Regulation	Less than 0.2% change for line voltage change 95 to 135 V ac and load change 1000 to 300 Ohms (10 to 33 mA).
POST REGULATOR (Excitation) continued	
Temperature Stability	Less than 0.003%/°F over temperature range +15°F to +150°F.
Time Stability	Less than 0.03% for 48 hours with constant line, load and temperature.
TRANSFER CHARACTERISTICS	
Gain Ranges (Switch S1 and Potentiometer R42)	
For accelerometers having Full Range Output of 175 to 675 mV:	Full Scale Output for 20%, 40%, 60%, 80% or 100% of Full Range Acceleration.
Accuracy	±1.5% of full scale
Frequency Response	±5%, dc to 20,000 Hz
Gain Stability	Less than ±0.1% for 24 hours plus ±0.005%/°F.
DC Linearity	Less than ±2.5 mV from best fit straight line through zero.
BRIDGE COMPLETION (Resistors R45 and R46)	Terminals provided for two completion resistors.
BALANCE LIMITING (Resistor R52)	40.2 k Ω resistor provided.
CALIBRATION (Resistors R47 through R51)	Resistors are provided for four steps of bipolar voltage substitution calibration. Amplifier output disconnected during calibration.

PHYSICAL

MODE CARD	Designed for plugging into front panel of Model 4470 Module.
CONTROLS (on Mode Card)	
Full Scale mV (Potentiometer R42)	Five turn potentiometer which calibrates system for specific accelerometer full scale output.
Range (Switch S1)	Five position switch which selects percentage of accelerometer output for full scale amplifier output. With Slide-in Label: selects full scale acceleration in g.
WEIGHT	200 grams (7 oz.) max.

Continued product improvement necessitates that Endevco reserve the right to modify these specifications and/or prices without notice.

RELIABILITY: Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures, together with conservative specifications, have made the name Endevco synonymous with reliability.

PRICES: (F.O.B. Pasadena) Model 4476.1 — $195.00 each

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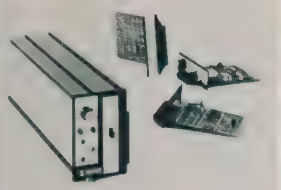


4470/4477.1

CHARGE AMPLIFIER

Full Scale Ranges from 10 to 300g for Transducer Sensitivities of 5 to 55 pC/g.

Useable with long input cables, up to 100,000 pF.

System Sensitivity independent of input cable length.

Flat Frequency Response, ±5%, 2 to 20,000 Hz.

Complete channel to channel isolation.

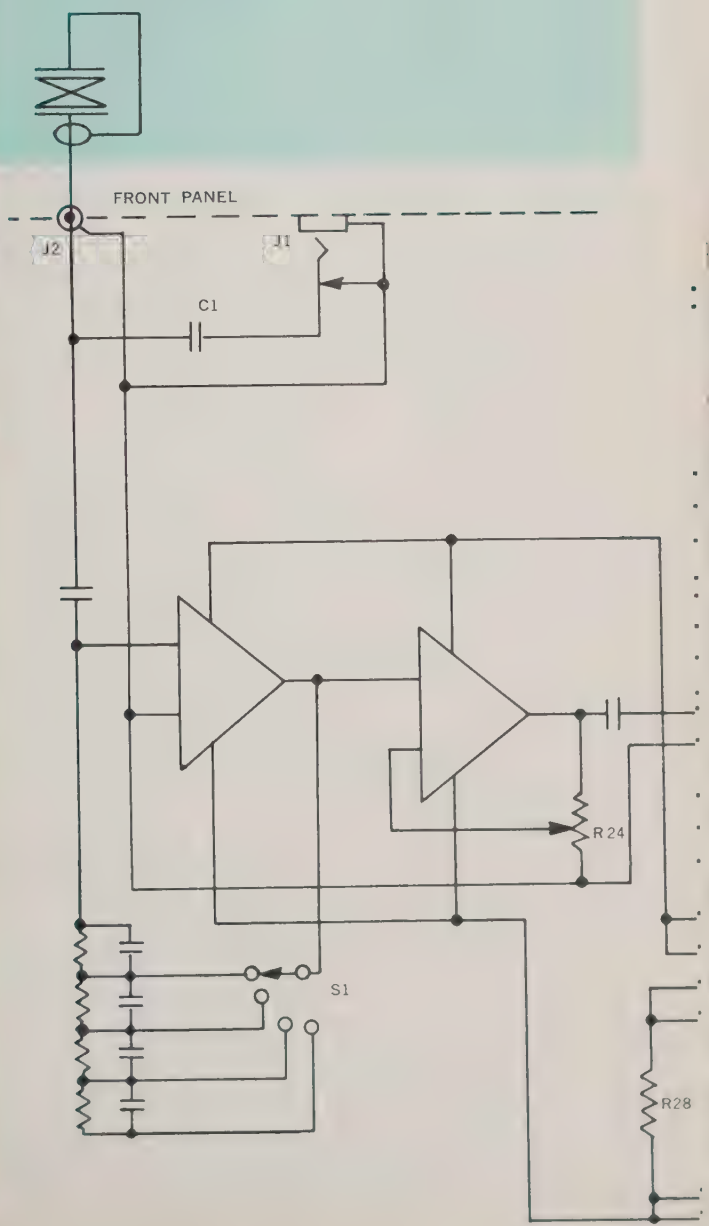
Integral and isolated power supply.

Calibrated Sensitivity Dial.

Shown at the right is a functional schematic of the 4477.1 Mode Card and a typical transducer. When this sheet is matched with the schematic in the 4470 Brochure, a complete functional schematic of the 4470/4477.1 Signal Conditioner results, showing transducer connections, calibration circuitry, and power supply operation.

Piezoelectric Transducers:

Accelerometers
Pressure Pickups
Force Gages
Impedance Heads



DESCRIPTION:

The Model 4477.1 Plug-in Mode Card is a charge amplifier designed for use with the Model 4470 Signal Conditioner Module. It is intended for use with piezoelectric or capacitive transducers.

The plug-in card contains a charge converter and a voltage amplifier with adjustable gain. The gain characteristics are such that the output voltage is proportional to the charge generated by the input transducer. With this characteristic, the transducer output and temperature response are independent of the cable length between the transducer and amplifier.

The isolated power supply in the Model 4470 allows multichannel operation with complete channel-to-channel isolation to prevent ground loops. A calibrated dial is provided to set in transducer sensitivity. Full scale output of ±2.5 Volts peak is obtained for input measurands of 10, 30, 100 or 300 g, psi, or lbs.

SPECIFICATIONS FOR 4470 with 4477.1 MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

INPUT CHARACTERISTICS	
Input Connection	Single ended
Source Impedance[1]	Capacitive devices only. Shunt resistance 50 MΩ, min.
Source Capacitance[1]	10,000 pF max., lowest two ranges. 100,000 pF max., upper two ranges.
Overload Recovery Time	For a 1 ms square pulse of 5500 pC amplitude at input,
Lowest two ranges:	3 ms max.
Upper two ranges:	1 ms max.
OUTPUT CHARACTERISTICS	
Output Connection	Single ended
Output Voltage	
Full Scale:	± 2.5 Volts peak
Overvoltage:	±7.5 Volts peak, nominal
Linear Output Current	±2.5 mA peak, maximum.
Output Impedance	20 Ohms, maximum.
Residual Noise	Less than the total of 0.02 pC rms plus 0.0025 pC rms per 1000 pF of source capacitance referred to input, or 1 mV rms referred to output, whichever is greater.
TRANSFER CHARACTERISTICS	
Gain Ranges, Full Scale for Sensitivities:	
.5 to 5.5 pC/g	100, 300, 1000, 3000 g
5.0 to 55 pC/g	10, 30, 100, 300 g
Actual Gain	0.15 to 50 mV/pC
System Accuracy	±1.5% of F.S., any range, source capacitance of 3500 pF or less, at +75°F (+24°C).
Gain Stability	Better than 0.3% per 1000 pF source capacitance on lower two full scale ranges. Better than 0.5% per 10,000 pF source capacitance on upper two full scale ranges. Better than ±1% with time and temperature.
Frequency Response	±5%, 2 Hz to 20,000 Hz
Linearity	±0.5% of reading from best straight line approximation to curve of output amplitude versus input amplitude.
Total Harmonic Distortion	.2% maximum
CALIBRATION (J1, C1)	Provision for external calibration signal applied at phone jack on front panel through 1000 pF ±1% capacitor.
WARMUP TIME[1]	30 minutes
POWER (R28)	+30 Volts dc from 4470 set by program resistor, R28, on mode card.

PHYSICAL

MODE CARD	Designed for plugging into front panel of Model 4470 Module.
CONNECTORS (on Mode Card)	
Input (J2)	Coaxial, 10-32 thread, Microdot S-50 Series or equivalent.
Calibration (J1)	Phone Jack — Mating Plug Switchcraft No. 780 not supplied.
CONTROLS (on Mode Card)	
Sensitivity (R24)	Five turn potentiometer, with calibrated turns dial.
Full Scale (S1)	Four position rotary switch.
GROUND	Signal ground is isolated from each other channel and rack enclosure.
WEIGHT	210 grams (7.5 oz.) maximum.

NOTE: [1]To meet all specifications.

Continued product improvement necessitates that Endevco reserve the right to modify these specifications and/or prices without notice.

RELIABILITY: Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design the support of stringent Quality Control requirements and compulsory corrective action procedures. These measures together with conservative specifications have made the name Endevco synonymous with reliability.

PRICES: (F.O.B. Pasadena) Model 4477.1 — $175.00 each

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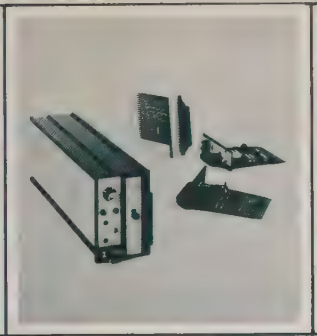


4470/4478.1A

CARRIER AMPLIFIER

Carrier Voltage 1 V rms
at 3000 Hz.

6 Selectable Gain Ranges

Vernier Gain Adjustment

Synchronous Demodulator

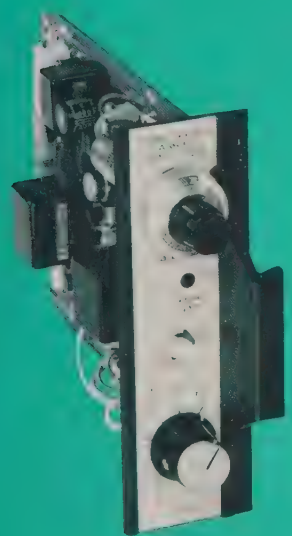
Bias for balance or offset of output

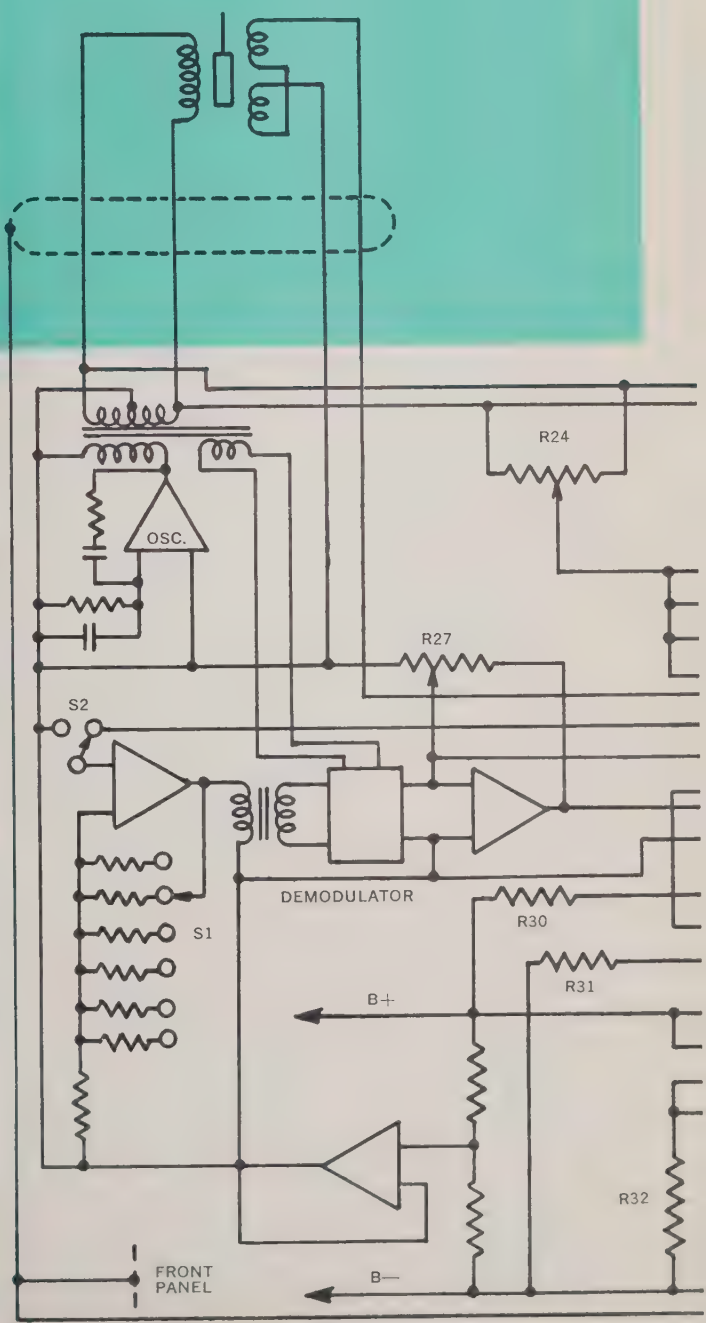
Adjustable bipolar calibration.

Linear Variable Differential
Transformers

Variable Reluctance Transducers

Shown at the right is a functional schematic of the 4478.1 A Mode Card and a typical transducer. When this sheet is matched with schematic in the 4470 Brochure, a complete functional schematic of the 4470/4478.1A results, showing transducer connections, power supply operation, calibration circuitry, and demodulation configuration.





DESCRIPTION:

The Model 4478.1A Plug-in Mode Card is carrier amplifier and demodulator designed for use with the Model 4470 Signal Conditioning Module. It is intended to provide carrier excitation to and demodulate the signal from linear variable differential transformers and variable reluctance type transducers.

Circuitry on the card provides ac excitation voltage, amplification, synchronous demodulation, filtering, offset and calibration voltages. Six gain step ranges plus a vernier adjustment allows selection of gain from less than one to 100. Output bias (offset) is adjustable by means of Balance potentiometer R28 on the 4470 Module. A turns counting dial on the calibration potentiometer provides accurate setting of calibration signal, with a span equal to the carrier amplitude.

SPECIFICATIONS FOR 4470 with 4478.1A MODE CARD

(Also see Specifications for Model 4470 Module)

ELECTRICAL

CARRIER EXCITATION	
Voltage	1 V rms ±2% (open circuit)
Frequency	3000 Hz ±5%
Distortion	2% maximum
Output Impedance	60 Ohms nominal
INPUT CHARACTERISTICS	
Input Connection	Single ended
Input Impedance	1 MΩ minimum
Source Impedance	10 kΩ maximum
OUTPUT CHARACTERISTICS	
Output Connection	Single ended
Linear Output Voltage	±2.5 V peak, full scale
Overvoltage	±5 V peak, nominal
Linear Output Current	±2.5 mA peak
Ripple and Noise	5 mV rms max., at maximum output. 2 mV rms max., at null.
Output Impedance	200 Ohms maximum
Stability[1]	±1% of full scale for 24 hours ±0.1%/°F
Output Bias	±2.5 V dc, minimum
TRANSFER CHARACTERISTICS	
Gain Ranges (S1)	2, 5, 10, 20, 50, 100
Vernier Gain (R27)	<0.4 to>1.0, continuous
Gain Step Accuracy	±2%
Linearity	±0.25% of reading
TRANSFER CHARACTERISTICS continued	
Frequency Response	dc to −3 db at 300 ±30 Hz
CALIBRATION	
(Potentiometer R24)	During calibration, transducer input is disconnected and wiper arm of R24 connected in its place. Output bias control R28 is also disconnected during calibration.
GROUND	Signal ground is isolated from each other channel and rack enclosure.
WARMUP TIME	20 minutes.

PHYSICAL

MODE CARD	Designed for plugging into front panel of Model 4470 Module.
CONTROLS (on Mode Card)	
Calibrate (R24)	Ten turn potentiometer, with turns counting dial.
Vernier Gain (R27)	Screwdriver adjustable single turn potentiometer.
Gain (S1)	Six position rotary switch.
Amplifier Zero (S2)	Pushbutton switch disconnects transducer and connects amplifier input to circuit ground.
WEIGHT	225 grams (8 oz.) max.

NOTES

[1]Stability includes the combined effects of changes at the output due to changes in carrier excitation, amplifier gain, amplifier zero and output bias voltage.

RELIABILITY: Endevco maintains a program of constant surveillance over all products to ensure a high level of reliability. This program includes attention to reliability factors during product design, the support of stringent Quality Control requirements, and compulsory corrective action procedures. These measures together with conservative specifications, have made the name Endevco synonymous with reliability.

PRICE: (F.O.B. Pasadena) Model 4478.1A — $235.00 each

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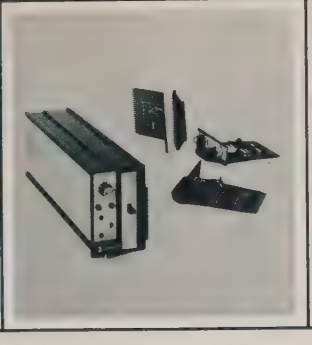
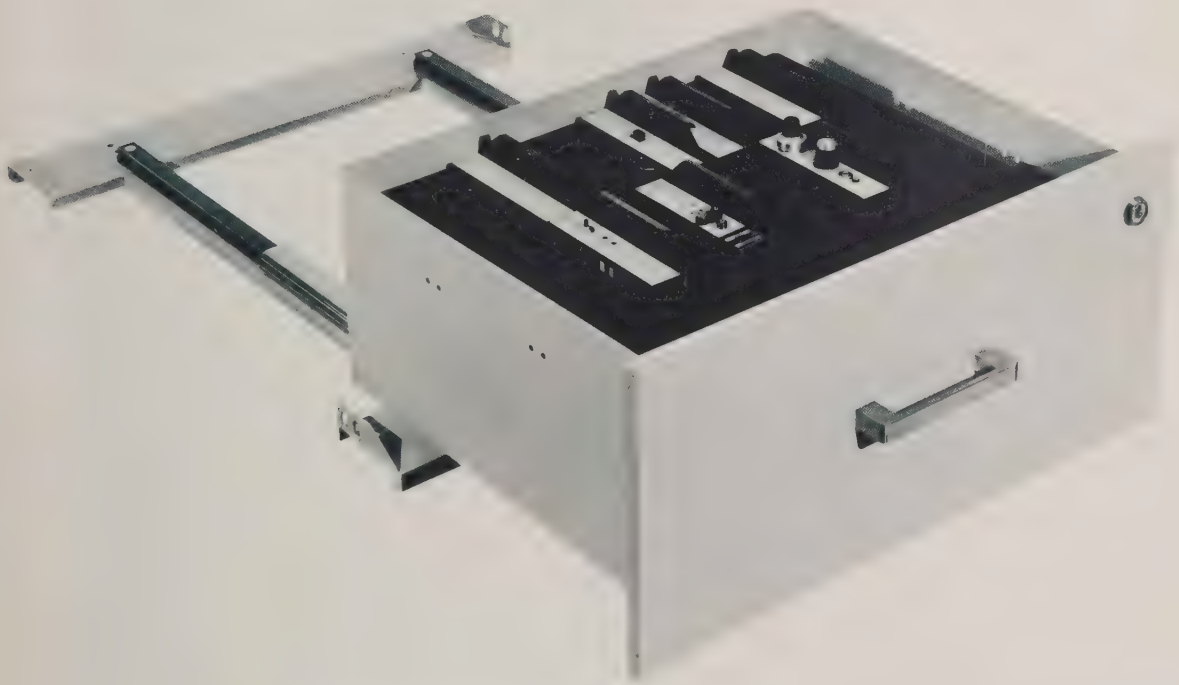


16111

STORAGE DRAWER
4470 SERIES MODE CARD

The Model 16111 Storage Drawer is designed to provide storage space and protection for ENDEVCO® Model 4470 Series Mode Cards. Up to 30 mode cards can be accommodated. Cards are stored vertically for easy access.

The drawer fits into a standard 19-inch relay rack or cabinet. Smooth action slides, to fit a 25-1/2 inch deep equipment rack, is supplied. A lock is provided on the front panel to prevent unauthorized access to the mode cards. Two keys are supplied.



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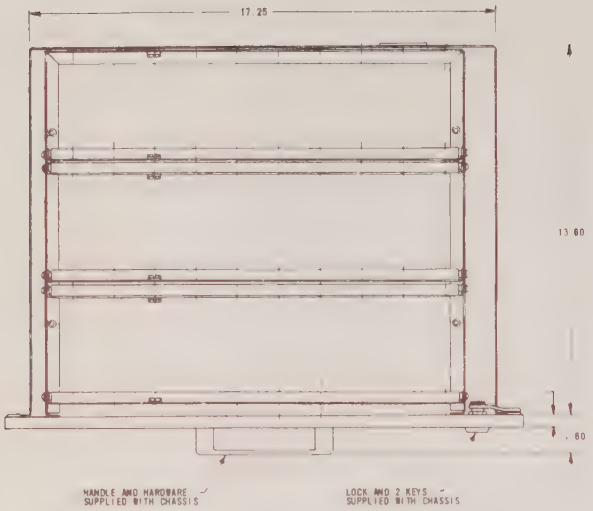

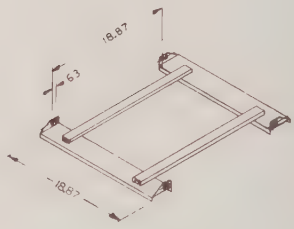

SPECIFICATIONS FOR MODEL 16111

DIMENSIONS	19 in. wide, 8.75 in. high, 13.6 in. deep. Front panel 1/2 in. thick.
FINISH	Grey enamel, Color No. 26595 per Federal Standard 595.
WEIGHT	28.5 lb.
ACCESSORIES SUPPLIED	Two keys for lock. Drawer slides and support channels. Mounting hardware.

Continued product improvement necessitates that Endevco reserve the right to change these specifications and/or prices without notice.

PRICE: (F.O.B. Pasadena) Model 16111 $150.00 each

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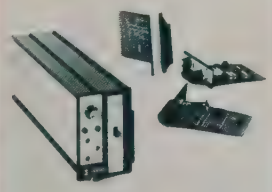

4470 SYSTEMS

PRICES & ACCESSORIES

1 JAN. 1969

		Unit Price
Master Module		
4470.000	Universal Signal Conditioner	$280.00
Optional Calibration Relays (designated by numerals after decimal point)		
.00X	Calibration step relays (specify 0, 1, 2, 3 or 4)	7.50
.0X0	Calibration polarity relay (specify 0 or 1)	7.50
.X00	Zero calibration relay (specify 0 or 1)	10.00
Plug-in Mode Cards		
4471.1	Voltage regulated, Resistive Bridge Signal Conditioner	20.00[1]
4471.2	Current regulated, Resistive Bridge Signal Conditioner	35.00[1]
4471.3	Potentiometer Signal Conditioner	25.00[1]
4472.1	ACCUMODE Signal Conditioner	30.00[1]
4473.1	RTB Signal Conditioner, Voltage Insertion Calibration	60.00[2]
4473.2	RTB Signal Conditioner, Resistance Substitution Calibration	60.00[2]
4474.1	Thermocouple Signal Conditioner	50.00[1]
4475.1	Designers Card	30.00
4476.1	Piezoresistive Accelerometer Signal Conditioner	195.00[1]
4477.1	Charge Amplifier	175.00
4478.1	Carrier Amplifier	235.00
Enclosures		
4942	Rack Adapter, fully wired with individual MS connectors for transducers and outputs, five channel, mating connectors furnished.	350.00
4943	Rack Adapter, wired for power, relays and monitor only.	250.00
2993	Carrying Case, single channel	75.00
Miscellaneous Accessories		
2995	Signal Monitor, five channel	675.00
4815	Transducer Simulator (used for calibrating 4477.1 card)	185.00
EP268	Module mating connector	12.50
13423	Mode card extender board	65.00
15769	Convenience cable	70.00
16059	Blank Panel	7.50

[1] Calibration or bridge completion resistors can be installed if specified at time of order, add $5 per resistor plus $10 per card.

[2] Price for existing temperature range/ice point combinations. There is a $300 one-time charge for new ranges.

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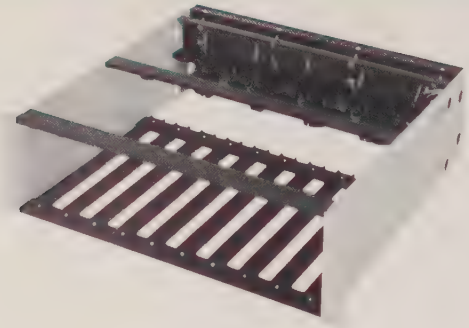
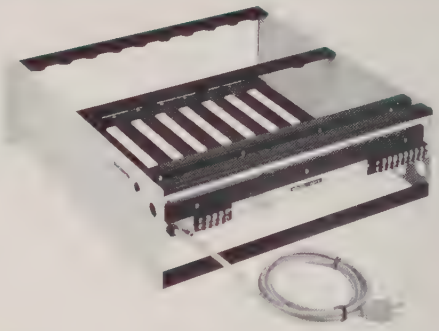
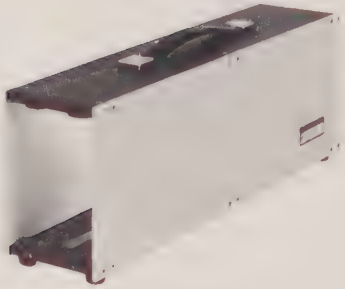
4470 System enclosures and accessories



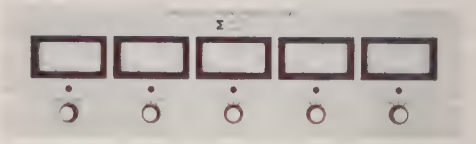
Model 4942
Rack Adapter, wired



Model 4943
Rack Adapter, unwired

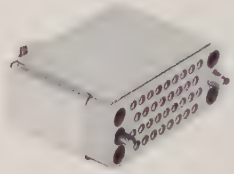


Model 2993
Carrying Case

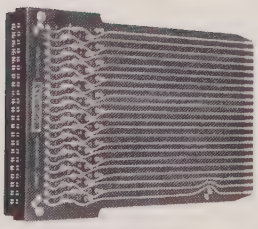


Model 2995
Signal Monitor

15769
Convenience Cable



EP268
Module Mating Connector



13423
Mode Card Extender Board

16059
Blank Panel

ELECTRICAL SPECIFICATIONS

Power Supply Specification

As a Voltage Regulated Supply (with 4471.1 Mode Card)

Output Voltage	1 to 30 V dc
Output Voltage Resolution	5 mV nominal
Output Current	0 to 100 mA
Current Limit Point	140 mA nominal
Line Regulation	Within 0.01% of setting or 500 μV whichever is greater for line changes from 95 to 135 V rms
Line Transient Response	No overshoot or ringing outside of the regulation limits for line transients from 95 to 135 V rms
Load Regulation	Within 0.01% of setting or 500 μV whichever is greater for load changes from no load to full load or full load to no load
Load Transient Response	Recovery to within 0.01% of setting in less than 50 μs for load changes from no load to full load or full load to no load
Noise and Ripple (normal mode)	100 μV pk-pk max., DC to 10 kHz
Output Impedance	.1 Ω to 2 kHz .5 Ω to 20 kHz
Temperature Stability	Less than 0.003% / °F of setting or 150 μV / °F whichever is greater
Time Stability	Within 0.03% of setting or 1.5 mV whichever is greater for 48 hours with line, load and temperature held constant
Sensing Current	312 μA
Resistance Programming	3.2 k ohms/volt ±0.1% plus ±2 mV

As a current regulated Supply (with 4471.2 Mode Card)

Output Current	0.5 to 5 mA low range 5 to 50 mA high range
Compliant Voltage Range	0 to 25 V dc
Voltage Limiting Point	35 V dc
Line Regulation	0.01% low range or 0.1 μA whichever is greater 0.02% high range
Load Regulation	0.01% low range or 0.1 μA whichever is greater 0.02% high range
Effective Output Shunt Capacitance	Less than 150 pF
Noise and Ripple (normal mode)	100 nA pk-pk max., low range 500 nA pk-pk max., high range DC to 10 kHz
Temperature Stability	Less than 0.003% / °F of setting
Time Stability	0.03% of setting for 48 hours with line, load and temperature held constant

System Specifications

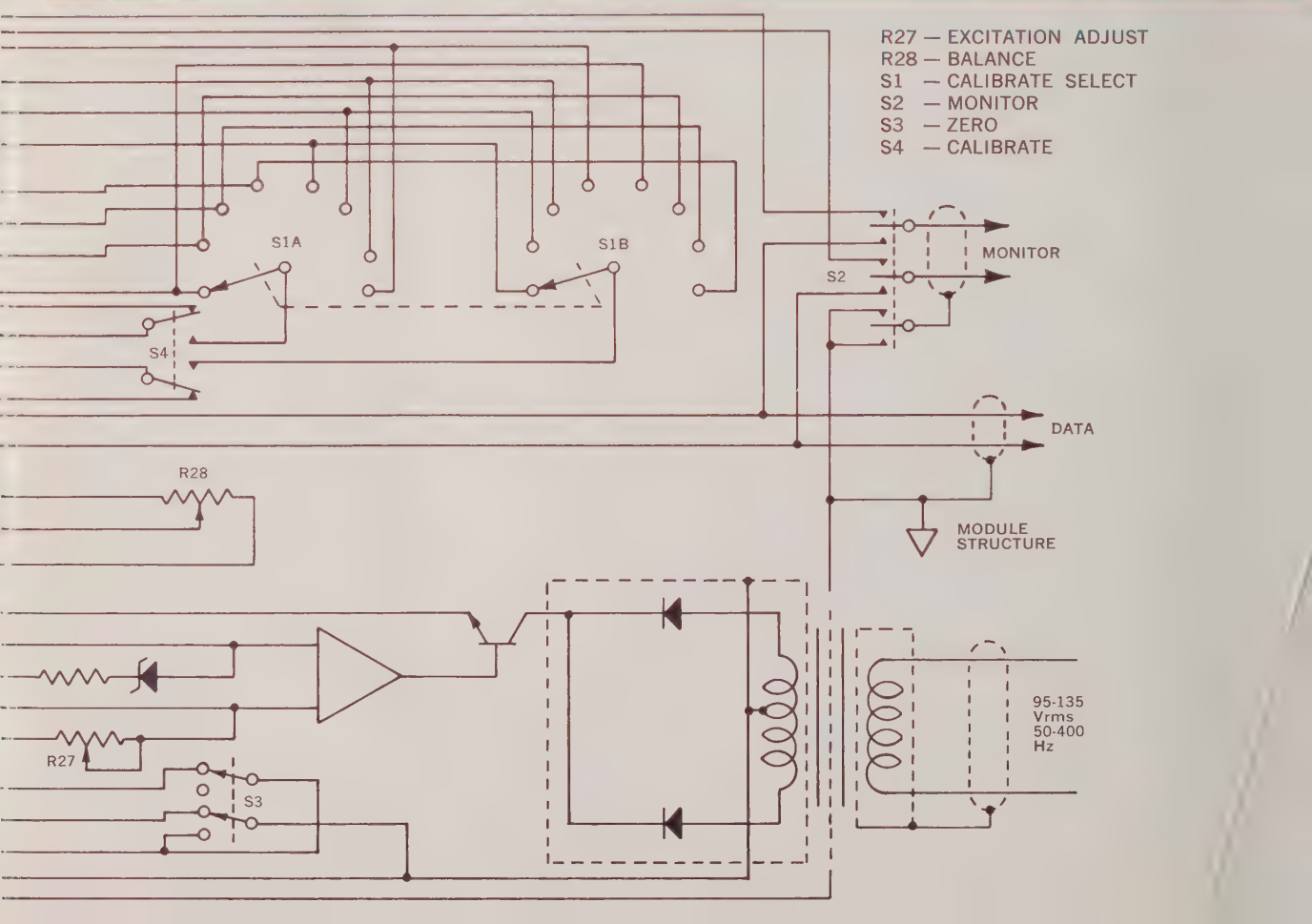
Noise to Ground	5 μV pk-pk across a grounded 350 ohm bridge
Effective Capacitance to Power Line	0.05 pF
Isolation Resistance	Greater than 100 GΩ from circuitry and chassis guard shield to primary and shield
Input Voltage	95 to 135 V rms (for 210 to 230 V rms specify 4470V)
frequency	50 to 400 Hz
power	9 watts nominal at median line voltage and full load
Optional Relays	
Voltage	24 ± 4 V dc
Current	8 mA nominal for polarity and calibration step relays 15 mA nominal for zero relay

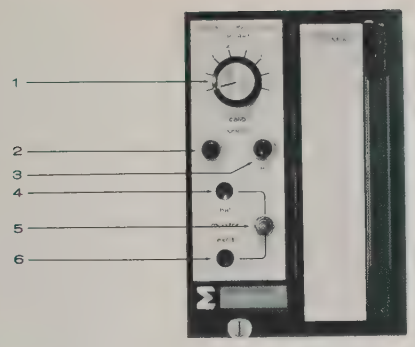
PHYSICAL CHARACTERISTICS

Size (module)	4⅞ in. high x 3²³⁄₆₄ in. wide x 13¼ in. deep (excluding connector)
Weight	5 lbs., 14 oz.
Finish	Grey enamel, Federal Standard 595, No. 26595 with black trim and lettering.
Mounting	Mounts five units wide in a standard 19-inch relay rack using Model 4942 or 4943 Rack Adapters — or singly in Model 2993 Carrying Case
Connectors, module	All connections to module are made through a single 34 pin, pin and socket type connector (Continental #25-34P)
Rack Adapter, Model 4942	Transducer connectors, MS3102A-20-27S (MS3106A-20-27P mating plug with MS3057-12 clamp included) with gold plated contacts
Rack Adapter, Model 4942	Output connectors, MS3102A-10SL-3P (MS3106A-10SL-3S mating plug with MS3057-4 clamp included) with gold plated contacts Relay control — Barrier strip, Cinch Jones #8-140 Y Monitor — Barrier strip, Cinch Jones #3-140 Y Power — Integral power cord, 6 ft. long with standard 3 prong line plug
Rack Adapter, Model 4943	Relay control, monitor and power connectors as above but unwired for signals and data.

ENVIRONMENTAL CHARACTERISTICS

Temperature, Operating	+15°F to +150°F (−9°C to +65°C)
Non-Operating	−65°F to +185°F (−54°C to +85°C)
Humidity	95%





CONTROLS

1 Calibrate Selector — An eight-position rotary switch is provided for selecting calibration levels. This will generally be four points of bipolar calibration, but eight steps of one polarity are possible with some mode cards.

2 Calibrate — A momentary pushbutton switch is used to connect the selected calibration level into the circuit.

3 Zero — Local "zero" calibration is provided by this momentary pushbutton switch, which removes the excitation from the load.

4 Balance — A ten-turn, 20 K ohm potentiometer is provided for adjustment of electrical zero of transducers. The control is recessed and screwdriver adjustable to minimize accidental change. Resolution is 0.017%.

5 Monitor — The monitor switch is a three pole, double throw toggle type (momentary-off-momentary) which alternately connects the excitation or the data output to a monitor common circuit in the rack adapter. The guard shield is also switched to maintain a continuous, isolated shield from transducer to the monitor meter.

6 Excitation — Front panel adjustment of power supply output (when resistance programming is not being used) is provided by this recessed, screwdriver adjustable control. This potentiometer is a ten-turn, 100 K ohm unit with a resolution of 0.01%.

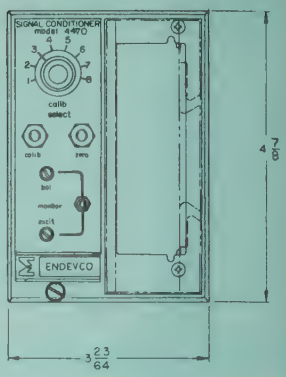
The heart of any signal conditioner for DC excited transducers is its power supply—and this one has the best. This all-silicon, solid-state supply is designed to optimumly provide either voltage regulation or current regulation of its output by mode card selection. The operating mode, be it constant voltage or constant current, resistance programmable or front panel adjustable, is set by the same card that determines conditioning and calibration. There will be no mixups because of a switch left in the wrong position with this system.

Among the really outstanding features of this supply are electronic current limiting with automatic recovery in the constant voltage mode (voltage limiting in constant current mode), external sensing capability with low sensing current (312 μA), and a really fast load transient recovery time (less than 50 μsec from no load to full load or full load to no load).

The Mode Card for a particular system (identified as 447X.X) contains the circuitry necessary to select and interconnect the components of the master module, as well as provision for mounting calibration and standardizing resistors. Special components required for that system and not provided in the master module are located on the plug-in card as well as active circuitry (amplifiers, oscillators, etc.) if required.

The broad base of capabilities of the 4470 system is apparent from the basic card series. Individual cards of a type are assigned sequential decimal numbers within each basic series as they are introduced.

- 4471.X Passive conditioning for variable resistance sensors in simple bridge circuits.
- 4472.X Passive conditioning for variable resistance sensors other than bridge.
- 4473.X Passive conditioning for variable resistance sensors in multiple bridge circuits.
- 4474.X Passive conditioning for self-generating sensors.
- 4475.X Miscellaneous passive conditioning modes.
- 4476.X Amplified variable resistance sensors.
- 4477.X Amplified self-generating sensors.
- 4478.X Carrier excited sensors.
- 4479.X Miscellaneous active conditioning modes.



CALIBRATION CONTROLS

Local calibration is accomplished by use of a two-pole, eight-position rotary switch to select the desired calibration level and a DPDT pushbutton switch which connects the selected level into the circuit. To retain the exceptional versatility provided by the plug-in mode card concept, all contacts are routed to the mode card without preassignment of function.

A DPDT form D (make before break) pushbutton switch is provided for local "zero" calibration. In the constant voltage mode, this switch connects the minus excitation and minus sensing leads before opening the excitation to the load. This technique prevents momentary loss of regulation during switching and the resulting voltage transient. In the constant current mode, the zero switch shorts the output of the supply and disconnects the load.

CALIBRATION RELAYS

Provision has been made in the 4470 for installation of relays to duplicate all local calibration functions. The use of remote calibration relays enables the calibrate sequence to be initiated from a location removed from the module itself. Probably more important, however, is the ability to calibrate all channels of an installation in parallel and at a rate far faster than could be done manually. This will minimize the amount of magnetic tape or oscillograph paper required to record calibration inputs prior to a test run.

The optional relays all have bifurcated, gold-plated, crossbar contacts and are enclosed in dust covers. Diode arc suppression is provided for each relay coil. All circuitry for the calibration relays is contained on the master circuit board so that relays can be added as a simple field addition if not included in the original order. The decimal portion of the master module model number describes the relays included in the original manufacture.

A zero in any position indicates no relay furnished, while a 1 indicates it has been provided (actual number of cal step relays is used as the last digit). A full compliment of relays would be designated by the number 4470.114, while a unit with no relays would be 4470.000.

RACKS AND ACCESSORIES Two rack adapters and a portable carrying case are available to house the 4470 Master Module. The 4942 Rack Adapter accommodates up to five 4470 modules for mounting in a standard 19-inch relay rack. The adapter is fully wired for transducer, relay power, monitor and AC power connections. Each channel is provided with individually wired MS connectors for transducer leads and output. The 4943 Rack Adapter has the power, relay and monitor connections prewired as in the 4942, but transducer and data connections have been left to the user.

The 2993 Portable Carrying Case provides a convenient means of operating single channels for bench use and provides the same degree of isolation and shielding as the rack adapters. Connections are made directly to the module by means of a 15769 Convenience Cable.

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INSTRUCTION MANUAL FOR
MODEL 4470 UNIVERSAL
SIGNAL CONDITIONING MODULE

1.0 GENERAL DESCRIPTION

1.1 Introduction

The Model 4470 Universal Signal Conditioning Module together with appropriate Plug-in Mode Cards comprises a system for conditioning the signals from a large variety of transducers. Among the types which may be accommodated are passive devices such as strain gages, resistance temperature bulbs, and piezoresistive transducers; self-generating devices including thermocouples and piezoelectric transducers; low level transducers requiring amplification; and carrier excited sensors.

The Model 4470 Signal Conditioning Module includes a solid-state, isolated dc power supply and those basic elements necessary to condition the outputs of a large variety of transducers. Features of the power supply include current limiting, external sensing, and fast load transient recovery.

Signal conditioning for many types of transducers is conveniently and rapidly accomplished by means of Mode Cards which plug into the front panel. Each series of card establishes the mode of operation for a particular type of transducer, and each card within a series establishes the signal conditioning for an individual transducer.

The power supply is readily converted from constant voltage to constant current operation by inserting the appropriate plug-in card. Once the plug-in cards are prepared, conversion from one type of operation to another, or from one type of transducer to another can be accomplished by simple card substitution.

Calibration circuitry in the Model 4470 provides a means for verifying the proper operating condition of each channel and also establishes reference output levels for future data reduction. Remote duplication of local calibration and zero functions is provided by installation of optional relays in the module.

Five Model 4470 modules may be mounted in a Model 4942 Rack Adapter which is designed to fit in a 19-inch rack enclosure. Each Model 4470 may also be operated on a bench or table outside the rack adapter.

1.2 Input Devices

Mode Cards are available for the conditioning of strain gage transducers, piezoresistive transducers, thermocouples, and temperature resistance bulbs, etc. Transducers operated in bridge circuits may include one to four sensing elements, since bridge completion resistors can be mounted on the individual Mode Card, where applicable.

In addition, a mode card is available for piezoelectric transducers. This card is a charge sensing circuit which converts the instantaneous electric charge to a voltage directly proportional to the charge.

A general list of mode cards is shown in Section 1.4. To obtain information on mode cards for specific applications or special transducers, see your local Endevco Field Engineer or write to Endevco.

It is recommended that the individual Mode Card Instruction Manual be reviewed for information on the capability or limitation of the series of cards described.

1.3 Output Devices

Allowable readout or output devices will depend on transducer and type of mode card. Usually the input impedance of the output device is 100 or more times greater than the output impedance of the transducer or mode card. See the individual mode card instruction manual and/or the transducer data sheet for output impedance information.

1.4 Mode Cards

Mode Cards are available for many applications. Individual cards of a type are assigned sequential decimal numbers within each basic series as they are introduced. The following list describes the basic types of mode cards:

4471.X	Passive conditioning for variable resistance sensors in simple bridge circuits.
4472.X	Passive conditioning for variable resistance sensors other than bridge.
4473.X	Passive conditioning for variable resistance sensors in multiple bridge circuits.
4474.X	Passive conditioning for self-generating sensors.

1.4 Mode Cards (continued)

4475.X	Miscellaneous passive conditioning modes.
4476.X	Amplified variable resistance sensors.
4477.X	Amplified self-generating sensors.
4478.X	Carrier excited sensors.
4479.X	Miscellaneous active conditioning modes.

1.5 Electrical Protection

The Model 4470 offers two electrical protection features. A 1/4 Ampere, 250 Volt slow-blow fuse is connected in series with one side of the input power line. Also, current limiting at approximately 140 mA is provided for the output of the circuit. The Model 4470 will not be damaged by an accidential short circuit across the power supply output.

2.0 PHYSICAL DESCRIPTION

2.1 Front Panel Controls

All controls and switches other than special features required for a specific type of conditioning are located on the module front panel. See individual Mode Card Instruction Manuals for information on the specific controls for each card.

2.1.1 Excitation Adjust (R27)

This control is a recessed, screwdriver adjustable, 10 turn, 100 k Ohm potentiometer used for adjusting the output excitation of the power supply.

2.1.2 Balance Adjust (R28)

This control is a recessed screwdriver adjustable, 10 turn, 20 k Ohm potentiometer used for adjusting the electrical output of bridge circuits to zero. It may be used for other purposes, depending on the Mode Card plugged into the module.

2.1.3 Calibrate Selector (S1)

The Calibrate Selector is a two-pole eight position rotary switch used for selecting the local calibration level. This switch is used in conjunction with the calibrate pushbutton switch.

2.1.4 Calibrate (S4)

This double-pole, double-throw pushbutton switch is used to connect the selected calibration level into the circuit.

2.1.5 Zero (S3)

This double-pole, double-throw, form D (make before break) push-button switch is used to provide the system with an electrical zero reference point. The switch disconnects excitation to the transducer in both the constant voltage and constant current mode.

2.1.6 Monitor (S2)

This is a triple-pole, double-throw (momentary-off-momentary) toggle switch used to monitor the excitation voltage or current of the power supply and the signal output. When actuated the switch connects the excitation or signal to a common monitor line in the rack. In the constant current mode the voltage across a precision 10 Ohm sensing resistor is monitored. The module guard shield is also connected through the switch when actuated, to maintain shield integrity all the way to the monitor meter.

2.2 Module Rear Panel Connector (J1)

The rear panel connector on the Model 4470 Module is a 34 terminal, Continental 25-34P connector. It mates with the Burndy MS34RM-1 on the rack adapter, or Model EP268 Hooded Connector for operation on a bench.

2.3 Mode Card Insertion

The front panel contains an opening for the insertion of the mode conversion plug-in card. This opening contains guides for the card and a Winchester printed circuit board connector, which is a receptacle for the card.

2.4 Model 4942 Rack Adapter

The Model 4942 Rack Adapter will accept up to five Model 4470 Modules. It is 5-1/4 inches high and mounts in a 19-inch rack enclosure. Guide rails ensure that the connector on the rear of the 4470 Module will mate correctly with the Burndy MS34RM-1 in the adapter. The modules are held in place on the adapter by the knurled captive screws mounted on the module. Optional blank panels, Model 16059, may be used to cover all vacant positions.

2.4.1 Connectors

The input connector (J3) is a 14-pin MS-3102A-20-27S-A95 with gold plated contacts. Mating cable connector MS-3106A-20-27P-A95 is supplied.

The signal output connector (J2) is a 3-pin MS-3102A-10SL-3P-A95 with gold plated contacts. Mating cable connector MS-3106A-10SL-3S-A95 is supplied.

Relay power input for all five channels is connected to an 8 point terminal strip (TB2), Cinch-Jones 8-140-Y or equivalent.

Monitor output for all five channels is obtained from a three point terminal strip, Cinch-Jones 3-140-Y, or equivalent.

The three-conductor integral power cord is 5 feet long and is terminated with a standard 3-prong line plug. The ground wire is connected to the primary shield of the power transformer. When the adapter is ordered for 230 Volt operation the plug is removed and the ends of the cable are pig-tailed and labeled.

2.5 Model 4943 Rack Adapter

The Model 4943 Rack Adapter is similar to the Model 4942 except that transducer and data connections are not supplied. Power, relay, and monitor connections are prewired as in the 4942. A quantity of EE125 Crimp Sockets (Burndy No. SC20M-1) are provided to allow termination of customer wires in the module mating connector J1 (Burndy No. MS34RM-1).

2.6 Bench Top Operation

The Model 4470 Module may be operated on a bench or in the Model 2993 Carrying Case as an individual unit. The optional EP268 Hooded Connector or 15769 Convenience Cable Assembly mates with the Continental connector on the Module.

3.0 CIRCUIT DESCRIPTION

Refer to Drawing C-4470.1-501C

3.1 Power Transformer

Isolation from the line is achieved by the use of a triple shielded power transformer (T1). The primary shield is connected through the module and rack wiring to the third wire of the power cord (power line ground). A second shield which separates the primary and secondary shields is connected to the module chassis and serves as the common mode shield. The two secondary windings are each individually shielded and the shields tied to their respective center taps. Magnetic interference from the transformer to the low level output leads is reduced by external magnetic shielding and a steel can around the transformer.

3.2 Plus and Minus 12 Volt Regulated Supply

One secondary winding of the power transformer is connected to a full wave rectifier CR1. This rectifier and filter capacitors C3 and C4 provide the unregulated voltages for the plus and minus 12 Volt regulated supply. A simple series regulator consisting of Q1, Q13, CR3 and C6 control the -12 Volt dc output. Similarly, Q2, Q14, CR4, and C7 control the +12 Volt dc output. The regulators provide the plus and minus operating voltages for the error sensing amplifier and reference circuit.

3.3 Excitation Supply

3.3.1 Regulation

The other secondary winding of the power transformer is connected to a full wave rectifier CR2. This rectifier and filter capacitors C5 and C8 provide unregulated positive voltage to a series regulator, and an unregulated negative voltage which offers a discharge path for the regulated output through R17.

Excitation voltage is controlled by the Darlington connected series regulator consisting of transistors Q6 and Q7. The regulator is controlled from the collector of transistor Q4 in the error amplifier.

3.3.2 Current Limiting

The unregulated filtered positive output of rectifier CR2 is connected through the current sensing resistor R5 to the emitter of current limiting

3.3.2 Current Limiting (continued)

transistor Q5. Zener diode CR5 and resistor R7 provide the base reference voltage for Q5. At normal output currents Q5 operates in a saturated condition. As the output current increases above the maximum rated limit, the voltage drop across R5 increases until it is equal to the voltage of the Zener diode minus the base to emitter voltage of the series transistor Q5. This transistor is biased toward cutoff, increasing the emitter-collector voltage drop and thus limiting the excitation output current.

3.3.3 Voltage Limiting

Normally, the Zener diode CR7 is non-conducting and has no control in the circuit. If the voltage at the base of Q7 increases to a magnitude equal to the breakdown voltage of CR7, the diode will conduct. The base of Q7 is then limited at this voltage preventing the excitation output voltage from increasing above 35 V dc.

3.4 Reference Bridge Circuit

The output of the +12 V dc regulator is connected to a constant current circuit consisting of R6, CR6, Q8, C12, R9, and R14. This circuit provides constant current for the temperature compensated Zener reference diode CR8 and sensing current for biasing the comparison bridge circuit. CR8 together with R19 and R21 form the reference half of the bridge comparison circuit. The regulated excitation voltage, as sensed by the sensing leads, and R27 form the other half of the bridge circuit as shown in Figure 1.

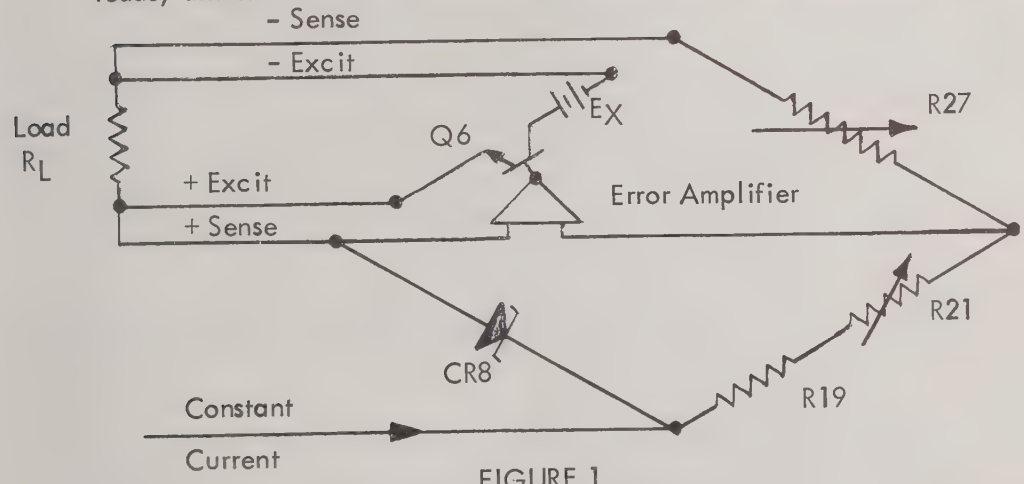


FIGURE 1

REFERENCE BRIDGE CIRCUIT

3.5 Error Amplifier Circuit

The amplifier is made up of three transistor pairs and associated circuitry. A matched pair of input FET transistors, Q11 and Q12, comprise a high

3.5 Error Amplifier Circuit (continued)

impedance differential amplifier stage. Operating current for this stage is controlled by a constant current source consisting of Q15 and R23. Potentiometer R25 is a balance control used to compensate for the difference in gate to source voltage of the input transistor pair. The second stage is made up of transistors Q9 and Q10 connected as emitter followers. The third stage is a second differential amplifier consisting of transistors Q3 and Q4.

The Error Amplifier acts as the detector in the four arm reference bridge, Figure 1. Any change in voltage appearing at the sensing leads unbalances the bridge producing an error signal at the input of the amplifier. The output of the error amplifier is applied to the series regulator, Q6 and Q7, in a direction to restore the excitation output to the desired magnitude and, thereby, restoring the output of the reference bridge to zero.

In the voltage regulated mode of operation, the sensing leads are connected across the output voltage, internally at the mode card, or externally at the load. In the constant current mode, the sensing leads are connected across current sensing resistors on the mode card. The block diagrams in Figure 2 illustrate these connections.

4.0 OPERATING INSTRUCTIONS

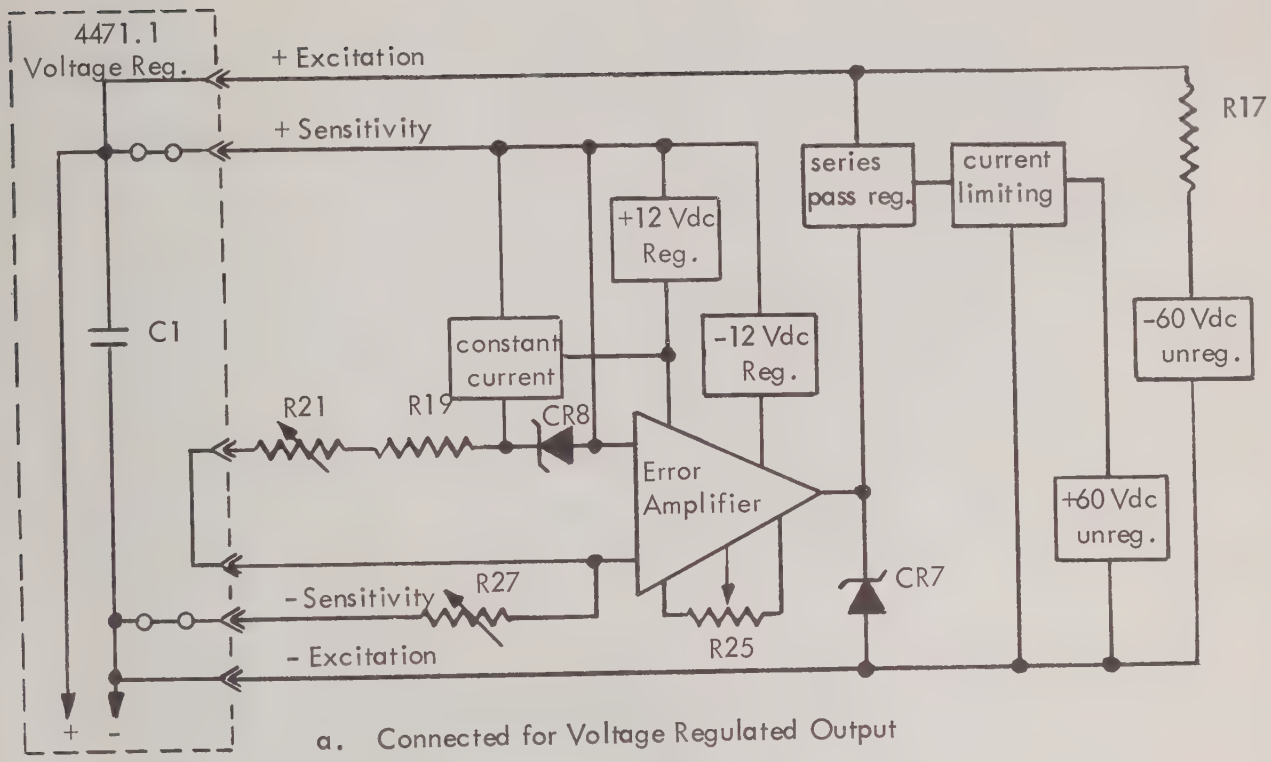
4.1 Mounting

Up to five Model 4470 Signal Conditioning Modules may be mounted in a Model 4942 or 4943 Rack Adapter, designed for standard 19 inch racks. All electrical connections are made through the connector on the rear of the module. The use of Model 16059 Blank Panel, one each per module space, is recommended to cover openings in the rack adapter where modules are not inserted.

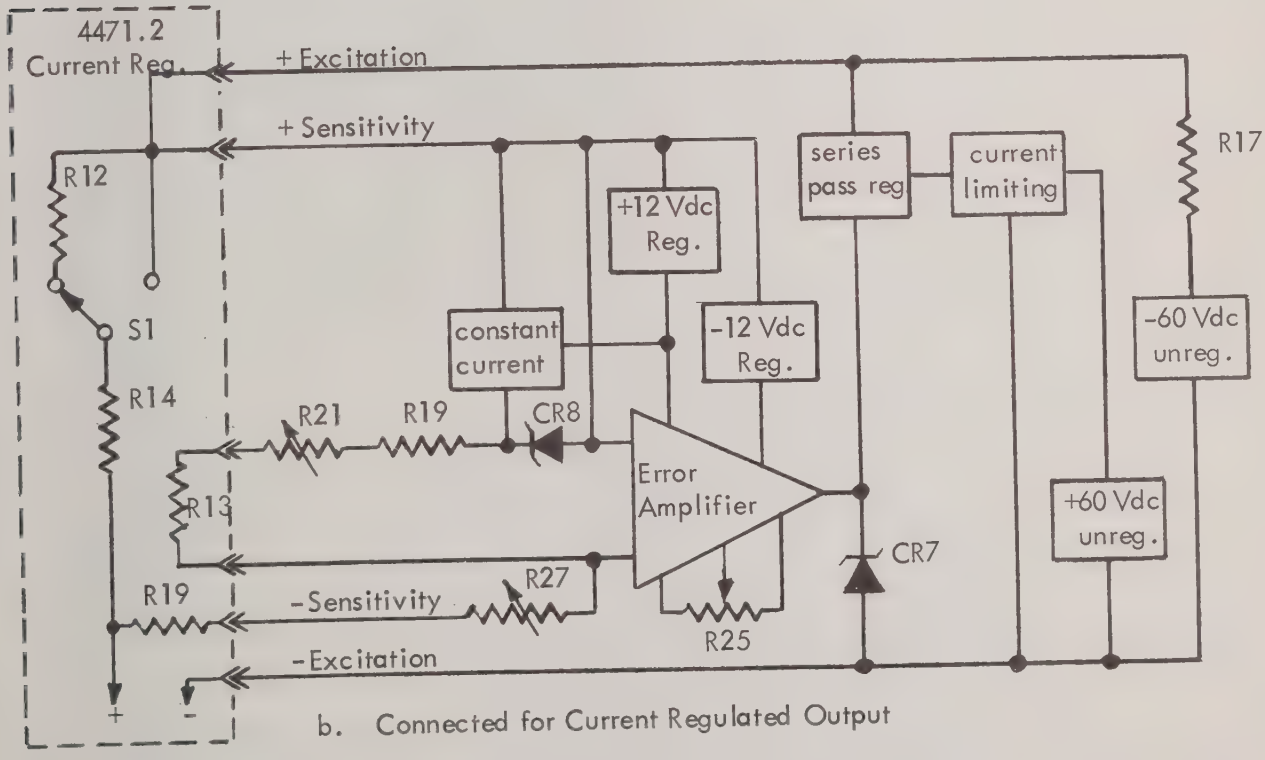
For bench use, the module may be connected by means of a hooded connector, EP268, or convenience cable assembly No. 15769.

4.2 Electrical Connections

The electrical connections to the module or rack adapter will depend on the transducer type and mode conversion card. See schematic Drawings 4470-501C for the module, and 4942-501C for the rack adapter enclosed with this manual.



a. Connected for Voltage Regulated Output



b. Connected for Current Regulated Output

FIGURE 2

BLOCK DIAGRAM OF MODEL 4470 MODULE

4.2 Electrical Connections (continued)

Connections for individual mode conversion cards are shown on the schematic drawings enclosed in separate instruction manuals supplied with each type of card.

4.3 Power

The Model 4470 operates from a line source of 95 to 135 Volts ac, 50 to 400 Hz. The module is energized when power is applied to the ac line plug. This feature permits a large number of modules to be energized by means of one rack power switch.

Modules and rack adapters identified with the suffix letter "V" are designed for operation on 190 to 270 Volts ac, 50 to 400 Hz power. The line plug on the rack adapter is removed and the power cord is terminated with tinned wires.

4.4 Mode Cards

Before inserting mode card into the signal conditioning module, read the instruction manual for the card. Turn the excitation adjust control counter-clock-wise to avoid damaging the transducer when power is applied.

A test adapter, Model 13423, is available to operate mode cards outside the module. Terminals on the test adapter allow attachment of clip leads for measuring voltages at the mode card input terminals.

A foldout schematic drawing of the Model 4470 follows the text of this manual. Insert the schematic drawings of the mode cards in front of this schematic. Together they provide a practical schematic of the mode card and signal conditioner showing all external and optional connections as well as the terminal connections on the Model 4942 Rack Adapter.

4.5 Relays for Remote Calibration

Up to six optional relays may be mounted in the Model 4470 Signal Conditioning Module (See Drawings 4470.XXX-1C and 4470-501C). These relays permit remote operation of controls which are normally operated at the module. They may be provided as a customer option or easily installed at a later date according to requirements. Note that diodes are installed across each coil to prevent transient voltages which may occur when the relay is de-energized.

When energized one at a time, relays K1 through K4 connect calibration resistors, mounted on the mode card, into the transducer circuit.

4.5 Relays for Remote Calibration (continued)

Resultant change in output signal is up scale at a magnitude depending on the value of the resistor.

K5 is a polarity reversal relay to provide bi-polar calibration. K6 is a zero calibration relay which disconnects the excitation to the transducer thus providing an electrical zero reference point. These relays are normally supplied for 24±4 Volt dc operation.

When any relay is omitted, jumpers connect Pin 5 to Pin 6 and Pin 8 to Pin 9 of the relay. When relay K6 is omitted, a jumper also connects Pin 11 to Pin 12. These jumpers must be removed when relays are installed in the field. Also, when a relay is omitted, its corresponding diode is replaced with a 3.3 k ohm ±5%, 1/4 Watt resistor to tie all unused leads together.

4.6 Temperature

The Model 4470, mode cards and rack adapter are designed to operate in a range of ambient temperature from +15° to +150°F. The air temperature above any Signal Conditioner should not be permitted to exceed +150°F.

5.0 INSTALLATION AND CHECKOUT

5.1 Unpacking and Inspection

This equipment has been thoroughly tested and inspected at the factory and should be ready for operation when received. However, the customer should make an inspection to be certain that no damage has occurred during shipment.

Carefully remove the instrument from its packing box. Inspect the equipment for any sign of external damage. Obvious damage should be reported immediately to the carrier.

5.2 Installation

The Model 4470 may be operated in a Model 4942 or 4943 Rack Adapter, in a 2993 Portable Case, or on a bench with connection made through an EP268 Hooded Connector or 15769 Convenience Cable. No ac power switch is provided and the Module is energized when the power line plug is inserted into a line receptacle. This provision allows a large number of modules to be operated from a single switch controlling power to a rack installation.

5.3 Connections

CAUTION: When connecting a Model 4470, ensure that the sensing leads are connected to their respective output or excitation wires somewhere in the system and that the polarity of the sensing leads agrees with the polarity of the power output leads. Failure to heed this caution may result in damage to the unit or transducer. See instruction manual for mode card for connection of sensing leads.

The electrical connections to the Module will depend on the transducer type and the mode card plugged into the unit. See the schematic drawing 4470-501C in this manual and also the schematic drawing in the Mode Card Instruction Manual.

5.4 Checkout Procedure

The following sections describe the recommended procedures for checking the operation of the Model 4470. These may be used during incoming inspection or for periodic maintenance.

These procedures are based on the use of a Model 4471.1 Voltage Regulated Bridge Conditioner Mode Card and a Model 4471.2 Current Regulated Mode Card. When using other cards, suitable corrections must be made.

5.4 Checkout Procedure (continued)

The following test equipment is required:

Oscilloscope (Tektronix Type RM561A with Type 2A63 Preamplifier, or equal)

Differential DC Voltmeter (John Fluke Model 801B or equivalent)

Variable Autotransformer, 95 to 135 Vac

Low Noise Decade Amplifier

True RMS AC Voltmeter

Resistors:
100 Ohm, 5 Watt
300 Ohm, 5 Watt
400 Ohm, 5 Watt
1,000 Ohm, 1/2 Watt
10,000 Ohm, 1 Watt
40,000 Ohm, 1 Watt

Resistance Bridge, 350 Ohm, made from four 350 Ohm, 0.1% resistors. Bridge must be shielded.

Switch, SPST

5.5 Checkout with Voltage Regulation Card

Plug Model 4471.1 Voltage Regulated Conditioner Mode Card into Model 4470 Module.

Connect the equipment as follows:

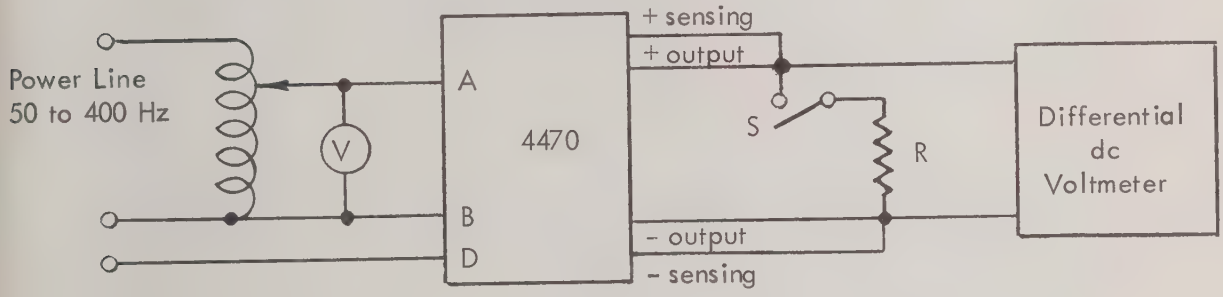


FIGURE 3

VOLTAGE REGULATION TEST CIRCUIT

Since the wires connecting the load will have a finite amount of resistance, the point of regulation must be established at the load itself. Care should be taken to ensure that the error sensing leads and measurement leads are connected directly to the load at one point.

Before each test adjust the voltage or current excitation to its minimum value.

5.5.1 Line Regulation Test

CAUTION: Observe polarity when connecting remote sensing leads.

a. Connect the equipment as shown in Figure 3, with R = 300 Ohms.
b. Adjust input voltage to 115 Vac. Allow 30 minutes for warmup.
c. Adjust power supply output voltage to 30 Vdc.
d. Vary the input voltage from 95 to 135. The change in output voltage should be 3.0 mV dc or less.
e. Close switch to resistor.
f. Repeat step d.

5.5.2 Load Regulation Test

a. Connect equipment as shown in Figure 3, with R = 300 Ohms.
b. Adjust input voltage to 115 Vac.
c. Adjust power supply output voltage to 30 Vdc.
d. Close the switch to the load resistor, then open the switch. The change in the output voltage should be 3 mV dc or less for load changes of no load to full load or full load to no load.

5.5.3 Current Limiting Test

a. Connect equipment as shown in Figure 3, with R = 100 Ohms, and switch.
b. Adjust input voltage to 115 Vac.
c. Adjust power supply output voltage to 10 Vdc.
d. Observe the reading of the voltmeter as the excitation adjust is increased to its full clockwise position. The voltmeter should read approximately 14 volts (approximately 140 mA through resistor). Maximum voltage should not exceed 17 Vdc.

5.5.4 Ripple Test

The Endevco specification for ripple and noise applies for a frequency band width of dc to 10 kHz, (3 db down at 10 kHz). To duplicate the procedure used at Endevco, the preamplifier or a filter must be adjusted to pass only the frequencies in this band.

a. Connect the equipment as shown in Figure 4, with R = 300 Ohms.
b. Set the oscilloscope to 1 mV/div.
c. Set preamplifier to X 10, and the high frequency cut-off at 10 kHz, if adjustable.
d. Adjust input voltage to 115 Vac.
e. Adjust power supply output voltage to 30 Vdc.
f. Vary the power supply input voltage from 95 to 135 Volts. The ripple as observed on the oscilloscope should be 1 mV pk-pk or less.

5.5.4 Ripple Test (continued)

g. Close switch to connect load
h. Repeat step f.

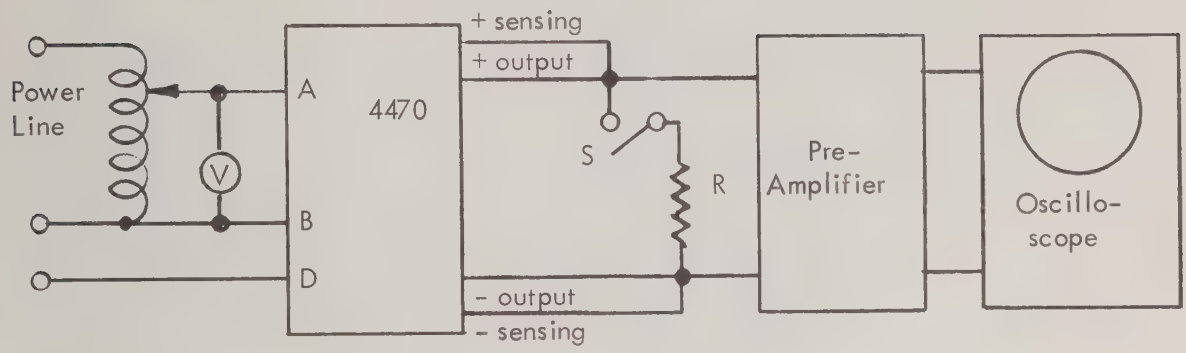


FIGURE 4

RIPPLE VOLTAGE TEST CIRCUIT

5.5.5 Noise-to-Ground Test

The extremely low noise and ripple generated by Model 4470 Signal Conditioner necessitates great care in the selection of test equipment. This measurement must show actual power supply noise while giving due consideration to the noise generated by the test equipment.

It is also very important to eliminate the possibility of noise generation due to ground loop currents flowing through the shields of the wires used in this test. Therefore, if the oscilloscope power cord is of the three-conductor type, a 3-to-2 adapter should be used to break the ground path.

In view of the small signal to be measured, a calibrated, noise free amplifier is required for an undistorted true measurement. All leads must be carefully shielded, as well as the bridge. All chassis and shields are tied together as shown in Figure 5, below. They must be grounded to the input of the oscilloscope, which is connected to power line ground or a good earth ground.

The noise contributed by the isolated supply will be the difference between the peak amplitudes of the oscilloscope display when the power supply is energized and when it is de-energized. With sufficient care in eliminating external noise from the system, this noise will be found to be 5 microvolts peak-to-peak or less.

5.5.5 Noise-to-Ground Test (continued)

For more information on the measurement of noise in power supplies, see the enclosed Tech Data No. 599.

CAUTION: Observe polarity when connecting remote sensing leads.

a. Connect the equipment as shown in Figure 5.

b. Adjust input voltage at 115 Vac.

c. Adjust power supply output to 10 Vdc.

d. The random noise across the 350 ohm bridge should be 5 μV pk-pk or less.

e. Reverse the ac power lines and repeat step d.

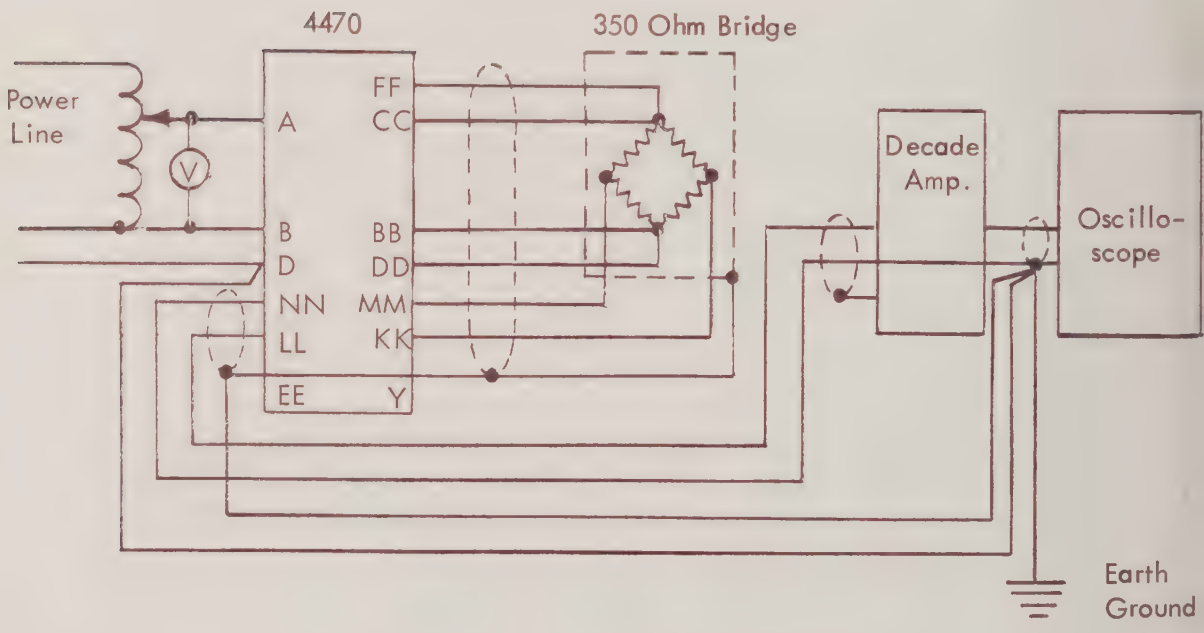


FIGURE 5

NOISE-TO-GROUND TEST

5.6 Checkout with Current Regulation Card

Plug Model 4471.2 Current Regulated Conditioner Mode Card into Model 4470 Module.

Connect the equipment as follows:

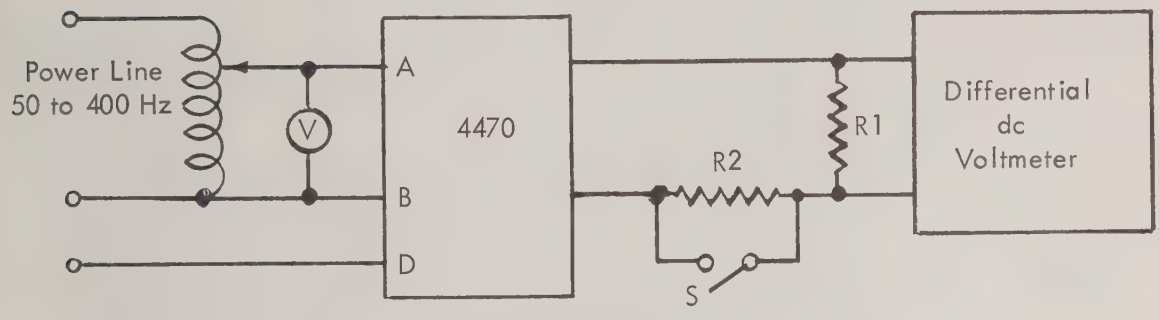


FIGURE 6

CURRENT REGULATION TEST CIRCUIT

5.6.1 Line Regulation Test

a. Connect the equipment as shown in Figure 6, with load resistors– R1 = 100 Ohms and R2 = 400 Ohms. Close switch S.
b. Set current range switch to high current, 5 to 50 mA.
c. Adjust input voltage to 115 Vac.
d. Adjust excitation for approximately 5 V output (50 mA).
e. Vary the input voltage from 95 to 135 Vac. The change in output voltage should be 1.0 mV or less (0.02%).
f. Open switch S and repeat step e.
g. Change resistor load– R1 = 10,000 Ohms and R2 = 40,000 Ohms. Set range switch to low current (0.5 to 5 mA). Adjust excitation to approximately 5 Vdc output (0.5 mA). Close switch S.
h. Vary the input voltage from 95 to 135 Vac. The change in output voltage should be 500 microvolts or less (0.01%).
i. Open switch S and repeat step h.

5.6.2 Load Regulation Test

a. Connect load resistors, R1 = 100 Ohms and R2 = 400 Ohms. Close switch S.
b. Set current range switch to high current, 5 to 50 mA.
c. Adjust input voltage to 115 Vac.
d. Adjust excitation for approximately 5 V output (50 mA).

5.6.2 Load Regulation Test (continued)

e. Open switch S (load 500 Ohms) and then close switch (load 100 Ohms). The change in output voltage should be 1.0 mV or less (0.02%).

f. Change resistor load to R1 = 10,000 Ohms and R2 = 40,000 Ohms. Set range switch to low current (0.5 to 5 mA). Adjust excitation to approximately 5 V output (0.5 mA).

g. Open switch S (load 50,000 Ohms) and then close switch S (load 10,000 Ohms).

The change in output voltage should be 500 microvolts or less (0.01%).

5.6.3 Ripple Test

The Endevco specification for ripple and noise applies for a frequency band width of dc to 10 kHz, (3 db down at 10 kHz). To duplicate the procedure used at Endevco, the preamplifier or a filter must be adjusted to pass only the frequencies in this band.

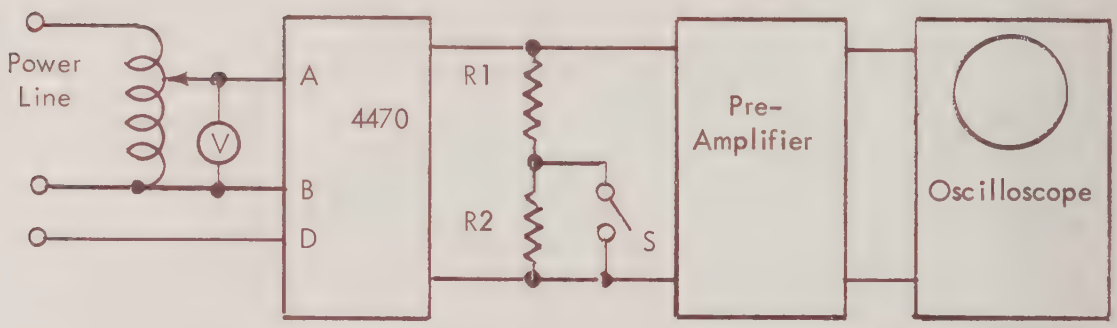


FIGURE 7

RIPPLE TEST CIRCUIT

a. Connect the equipment as shown in Figure 7, R1 = 100 Ohms and R2 = 400 Ohms. Open switch S.
b. Set current range switch to high current, 5 to 50 mA.
c. Set oscilloscope to 1 mV/div.
d. Set preamplifier to x 10, and the high frequency cutoff at 10 kHz, if adjustable.
e. Adjust input voltage to 115 Vac.
f. Adjust excitation for approximately 25 V output (50 mA).
g. Vary the input voltage from 95 to 135 Vac. The ripple as observed on the oscilloscope should be 2.5 mV pk-pk or less (500×10^{-9} A pk-pk, maximum).

5.6.3 Ripple Test (continued)

h. Remove preamplifier from circuit. Change resistor load, R1 = 10,000 Ohms and R2 = 40,000 Ohms. Set current range switch to low current (0.5 to 5 mA). Adjust excitation for 25 Vdc (0.5 mA).

i. Vary the input voltage from 95 to 135 Vac. The ripple as observed on the oscilloscope should be 5 mV pk-pk or less (100×10^{-9} A, maximum).

5.6.4 Noise to Ground Test

This test is similar to that performed with a Voltage Regulation Mode Card, see Section 5.5.5. Connect the equipment as shown in Figure 5, except that sensing leads are not used. Set current range switch to high current (5 to 50 mA) and adjust power supply output to 10 Vdc (approximately 29 mA). Follow the procedure described in Section 5.5.5. The output noise should be 5 microvolts peak-to-peak or less.

6.0 MAINTENANCE

Very little maintenance is normally required. However, a little preventative maintenance directed toward keeping the equipment in proper adjustment will go far toward assuring trouble-free operation when the equipment is needed.

All external connectors should be checked periodically for loose connections, shorts, or grounds. Also, periodic tests such as line and load regulation (Sections 5.5.1 and 5.5.2) will insure that the equipment is operating properly.

Since the error amplifier of the power supply is a DC coupled servo loop, failure of a component in any one stage will alter the voltages in all other stages, both succeeding and preceding the point of trouble. Voltage measurements on the transistors should be made with this in mind. The point of difficulty can best be localized by looking for a stage with contradictory operation; i.e., a transistor with base biased, and yet the transistor is not cut off as shown by a large voltage drop across the collector load resistor.

The regulating capabilities of the power supply are used to reduce the ripple in the output by a factor of approximately 1000. As a result of this, any malfunctioning in the power supply regulating circuitry will produce excessive ripple in the output.

When trouble shooting in the power supply, refer to Schematic Drawing C-4470.1-501C. This drawing identifies all components and also indicates the nominal dc voltages which should exist at the indicated terminals. Note that all test voltages are measured with reference to the + sensing line.

6.0 MAINTENANCE (continued)

Specially selected replacement components can be purchased from Endevco Corporation. Some of the components whose values must fall within certain prescribed limits, are selected by us for special circuit functions. Such selected parts, as well as the parts we manufacture at Endevco, are identified in the attached Electrical Parts List by notes or by our own five digit stock numbers.

If serious trouble occurs and the instrument cannot be repaired in the field, it should be returned to the factory with all transportation charges prepaid* A description of the malfunction and observed operation should accompany the instrument. See Warranty enclosed in this instruction manual.

7.0 DRAWINGS AND ADDENDA

This manual includes drawings showing outline dimensions, schematic diagrams, and parts list for this instrument. Other papers and assembly drawings of interest may also be included.

* Address all correspondence and shipment to:

Customer Service
Endevco
801 So. Arroyo Parkway
Pasadena, California 91109

ELECTRICAL PARTS LIST
MODEL 4470 SIGNAL CONDITIONING MODULE
MODEL 4942 RACK ADAPTER

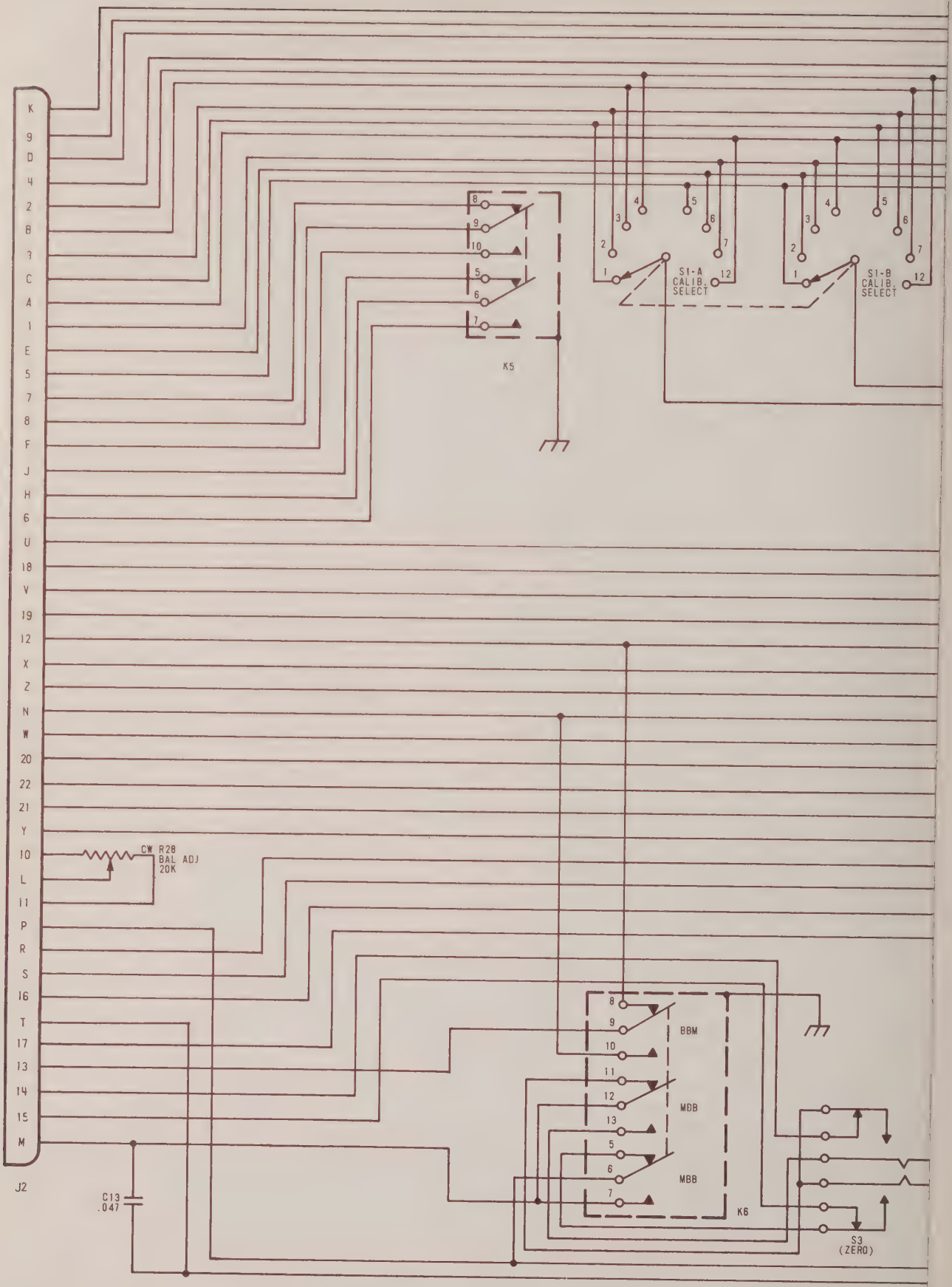
Des. No.	Part	Value and Description	Manufacturer and No.	Endevco Part No.
C1	Capacitor	0.1 µF, ±10%, 200 V, Mylar Film	Sprague 192P10492	EC469
C2	Capacitor	0.1 µF, ±10%, 200 V, Mylar Film	Sprague 192P10492	EC469
C3	Capacitor	50 µF, $^{+75}_{-10}$%, 50 V, Electrolytic	Sprague 30D506G 050DD4	EC347
C4	Capacitor	50 µF, $^{+75}_{-10}$%, 50 V, Electrolytic	Sprague 30D506G 050DD4	EC347
C5	Capacitor	10µF, $^{+50}_{-10}$%, 100 V, Electrolytic	Sprague 30D106F100DC2	EC602
C6	Capacitor	.01µF, 200 V, ±10%, Mylar	Sprague 192P10392	EC166
C7	Capacitor	.01µF, 200 V, ±10%, Mylar	Sprague 192P10392	EC166
C8	Capacitor	120µF, 75V		13043
C9	Capacitor	470 pF, ±5%, 500 V, Silver Mica	Elmenco DM-15-471J	EC224
C10	Capacitor	33 pF, ±5%, 500 V, Silver Mica	Elmenco DM-15-330 J	EC107
C11	Capacitor	470 pF, ±5%, 500 V, Silver Mica	Elmenco DM-15-471J	EC224
C12	Capacitor	.001µF, ±25%, 600 V, Paper	Sprague 192P10292	EC160
C13	Capacitor	.047µF, ±10%, 200 V, Mylar Film	Sprague 192P47392	EC466
CR1	Diode		Mallory FWL-100	ECR102
CR2	Diode		Mallory FWL-200	ECR99
CR3	Diode	1N759, Zener	Motorola	ECR121A
CR4	Diode	1N759, Zener	Motorola	ECR121A
CR5	Diode	1N749, Zener		ECR60
CR6	Diode	1N749, Zener		ECR60

Des. No.	Part	Value and Description	Manufacturer and No.	Endevco Part No.
CR7	Diode	Zener		15970
CR8	Diode	1N825	Motorola	ECR137
CR9	Diode	1N457	Sylvania	ECR182
CR10	Diode	1N457	Sylvania	ECR182
CR12	Diode	1N457	Sylvania	ECR182
CR13	Diode	1N457	Sylvania	ECR182
CR14	Diode	1N457	Sylvania	ECR182
F1	Fuse	Slo-Blo 0.25A, 250 V	Fusetron MDL	EF21
J1	Connector		Continental 25-34P	EP184
J2	Connector		Winchester 8BDJ22-M-0	15342
K1	Relay		Parelco R10-E-259-1	EK51
K2	Relay		Parelco R10-E-259-1	EK51
K3	Relay		Parelco R10-E-259-1	EK51
K4	Relay		Parelco R10-E-259-1	EK51
K5	Relay		Parelco R10-E-259-1	EK51
K6	Relay		Parelco R10-E-260-2	EK52
Q1	Transistor	2N3906	Motorola	EQ127
Q2	Transistor	2N696	Fairchild	EQ83
Q3	Transistor	2N3906	Motorola	EQ127
Q4	Transistor	2N3906	Motorola	EQ127
Q5	Transistor	2N3741	Motorola	EQ155

Des. No.	Part	Value and Description	Manufacturer and No.	Endevco Part No.
Q6	Transistor	2N3767	Motorola	EQ154
Q7	Transistor	2N910	Fairchild	EQ52A
Q8	Transistor	2N3906	Motorola	EQ127
Q9	Transistor	2N3904	Motorola	EQ130
Q10	Transistor	2N3904	Motorola	EQ130
Q11	Transistor	Matched Set		15310
Q12	Transistor			
Q13	Transistor	Selected FET (IDSS 4.8 to 6.2 mA)		15707
Q14	Transistor	Selected FET (IDSS 4.8 to 6.2 mA)		15707
Q15	Transistor	Selected FET (IDSS 4.8 to 6.2 mA)		15707
R3	Resistor	7.5K,±5%, 1/2W, Comp.	A.B. Type EB	ER719
R4	Resistor	12K, ±5%, 1/2W, Comp.	A.B. Type EB	ER249
R5	Resistor	22 Ω, ±5%, 1W, Comp.	A.B. Type GB	ER1344
R6	Resistor	390 Ω, ±5%, 1/2W, Comp.	A.B. Type EB	ER184
R7	Resistor	10K, ±10%, 1W, Comp.	A.B. Type GB	ER903
R8	Resistor	2.7K Ω, ±5%, 1/2W, Comp.	A.B. Type EB	ER197
R9	Resistor	7.5K, ±5%, 1/2W, Comp.	A.B. Type EB	ER719
R11	Resistor	100 Ω, ±5%, 1/2W, Comp.	A.B. Type EB	ER171
R12	Resistor	18K, ±5%, 1/2W, Comp.	A.B. Type EB	ER225
R13	Resistor	18K, ±5%, 1/2W, Comp.	A.B. Type EB	ER225
R14	Resistor	1.6K, ±5%, 1/2W, Comp.	A.B. Type EB	ER1023

Des. No.	Part	Value and Description	Manufacturer and No.	Endevco Part No.
R15	Resistor	100 K Ω, ±5%, 1/2W, Comp.	A.B. Type EB	ER233
R16	Resistor	47 Ω, ±5%, 1/2W, Comp.	A.B. Type EB	ER824
R17	Resistor	10K, ±10%, 1W, Comp.	A.B. Type GB	ER903
R18	Resistor	47 Ω, ±5%, 1/2W, Comp.	A.B. Type EB	ER824
R19	Resistor	18.90K, ±1%, 3W, W.W.	RCL Type T-2A	ER1754
R20	Resistor	20K, ±5%, 1/2W, Comp.	A.B. Type EB	ER671
R21	Potentiometer	2K, ±10%	CTS Type 115	ER1009
R22	Resistor	5.1K, ±5%, 1/2W, Comp.	with R26, balanced pair	ER2005
R23	Resistor	470 Ω, ±5%, 1/2W, Comp.	A.B. Type EB	ER156
R24	Resistor	100 Ω, ±5%, 1/2W, Comp.	A.B. Type EB	ER171
R25	Potentiometer	50 Ω, ±10%	CTS Type 115	ER1697
R26	Resistor	5.1K, ±5%, 1/2W, Comp.	with R22, balanced pair	ER2005
R27	Potentiometer	100K		13632-1
R28	Potentiometer	20K		13632-5
S1	Switch Assy.			15341
S2	Switch	3PDT, Toggle	C & K Comp. Inc #7305	ES95
S3	Switch	Pushbutton	Switchcraft #12S-1035	ES96
S4	Switch	Pushbutton	Switchcraft #12S-1020	ES41
T1	Transformer Assy. (115 V)			15339-1
T1	Transformer Assy. (230 V)			15339-2

Des. No.	Part	Value and Description	Manufacturer and No.	Endevco Part No.
	Mating Connectors			
	Hooded Connector, mates with J1		Continental 25034-16S and Hood 25034-16H	EP268
MODEL 4942 RACK ADAPTER				
J1	Connector, Module		Burndy MS34RM-1	EJ239
		Socket, Crimp	Burndy SC20M-1	EE125
J2	Connector	Signal Output	MS3102A-10SL-3P	EJ131
J3	Connector	Transducer Input	MS3102A-20-27S	EJ112
TB1	Terminal Block, Monitor		Cinch-Jones 3-140-Y	EE41
TB2	Terminal Block, Relay Power Input		Cinch-Jones 8-140-Y	EE62
	Mating Connectors			
	Signal Output, mates with J2		MS3106A-10SL-3S-A95	EP136
	Transducer Input, mates with J3		MS3106A-20-27P-A95	EP134


K
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D
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C
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10
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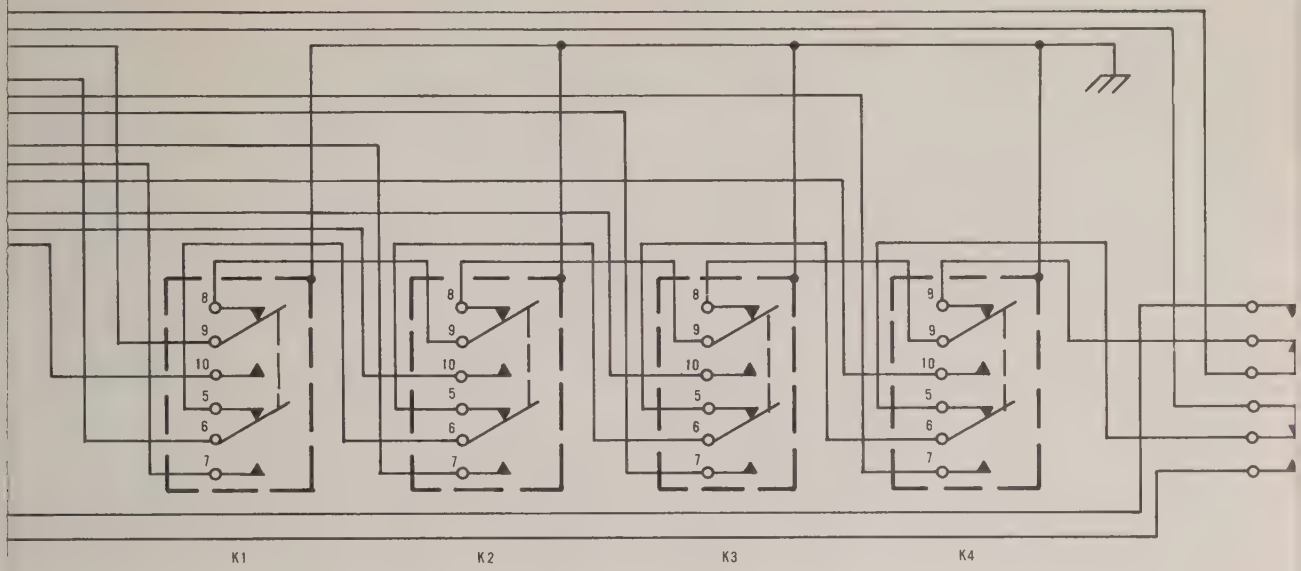
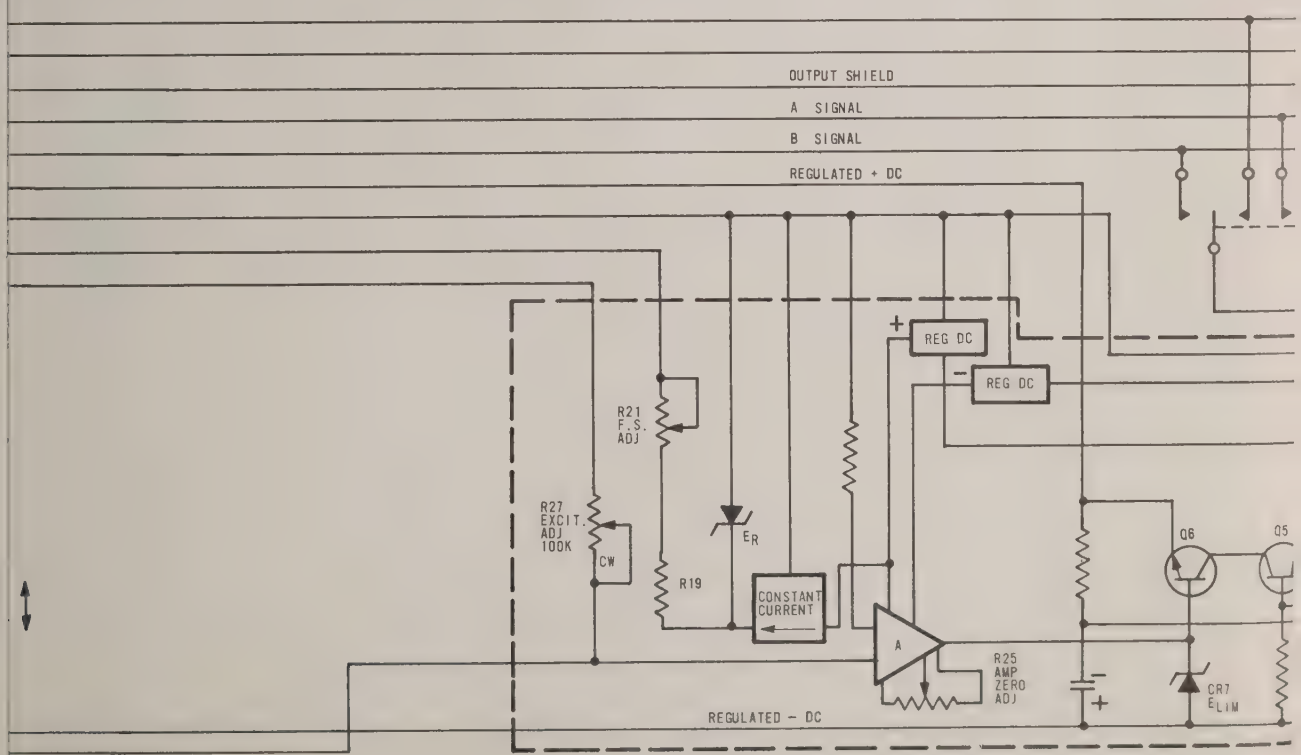
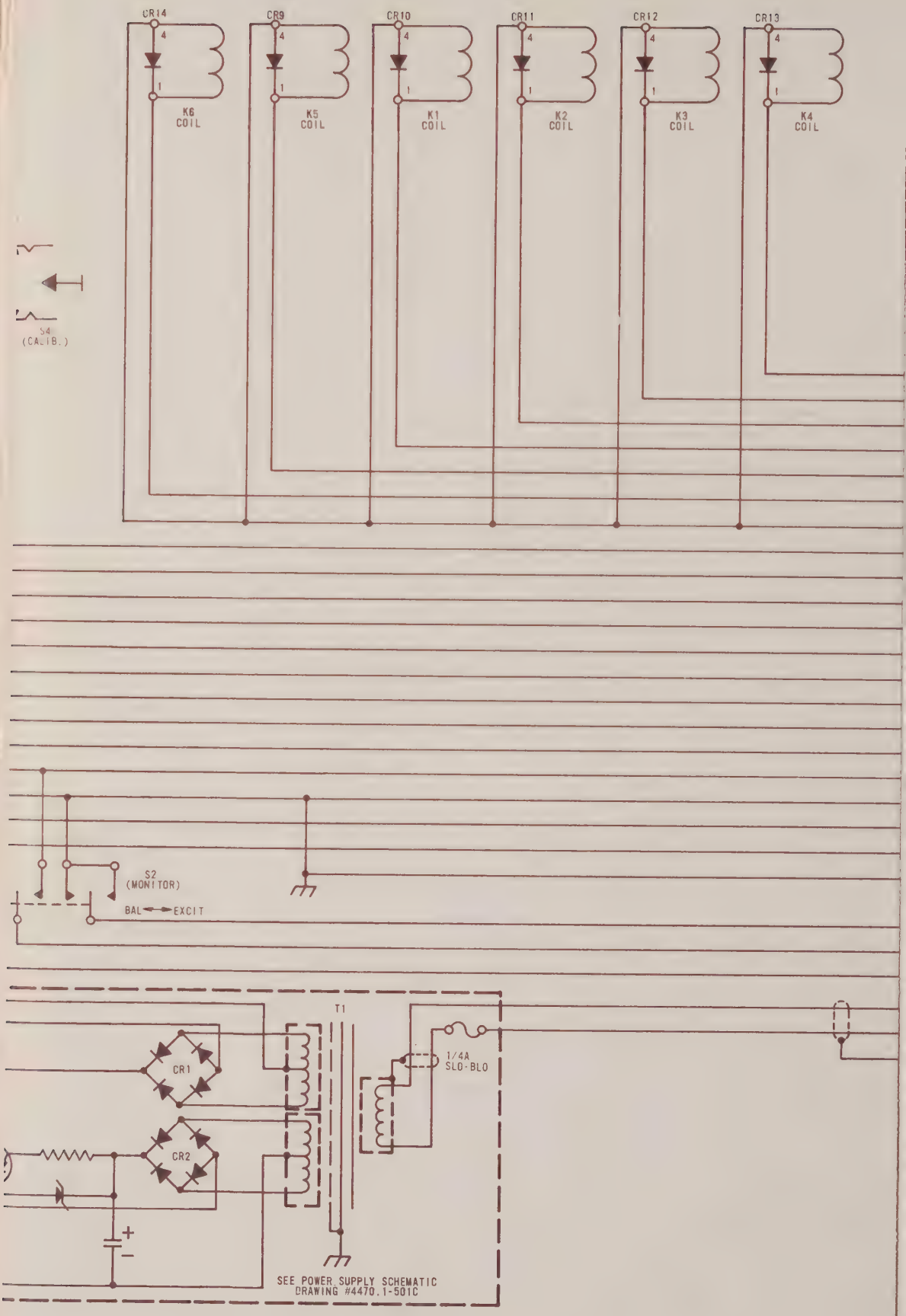
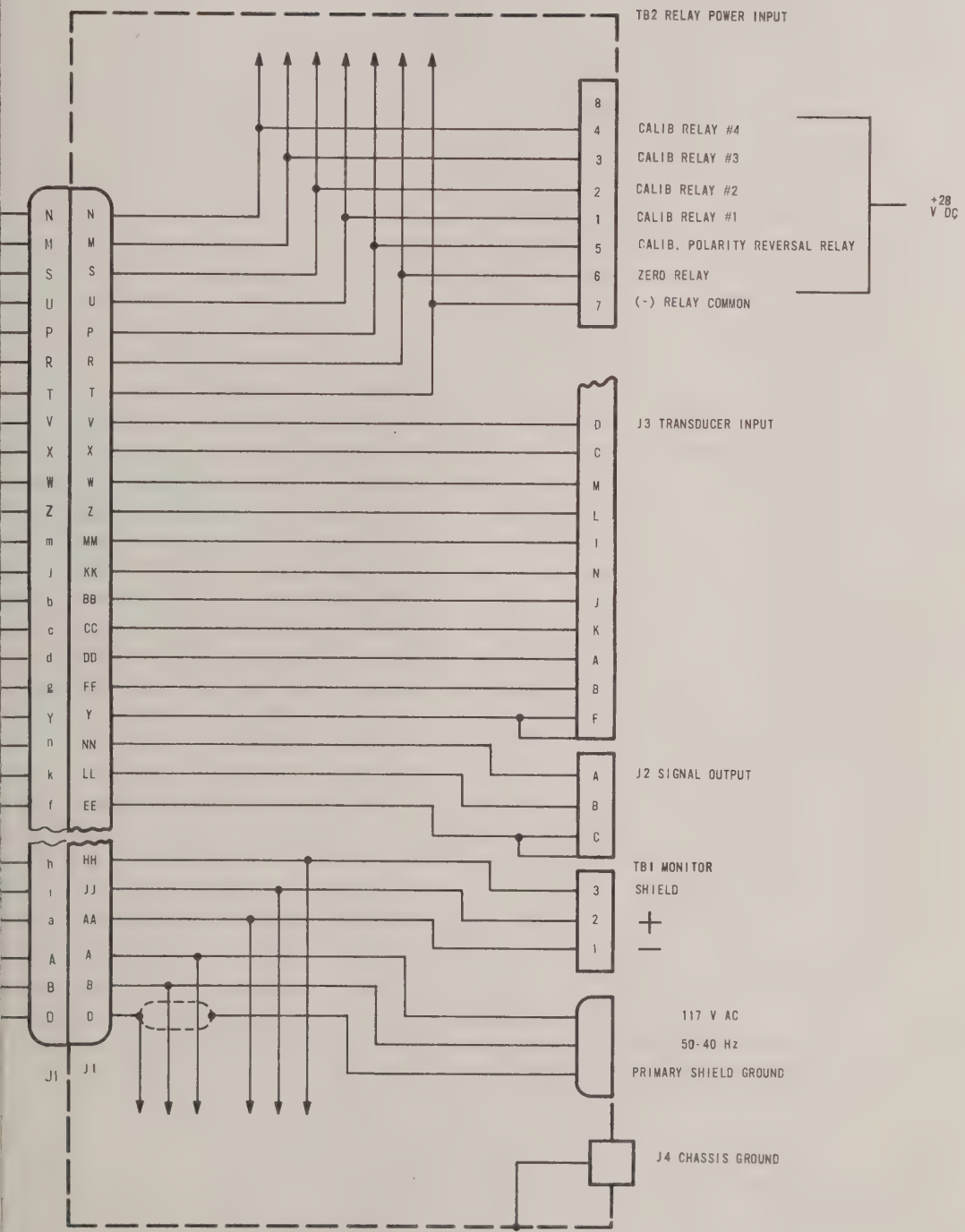
11
P
R
S
16
T
17
13
14
15
M
J2
K5
S1-A CALIB. SELECT
S1-B CALIB. SELECT
CW R28 BAL ADJ 20K
C13 .047
BBM
MBB
MBB
K6
S3 (ZERO)



NOTE: ALL NORMALLY CLOSED RELAY CONTACTS ARE CONNECTED WITH A JUMPER WHEN RELAY IS OMITTED.



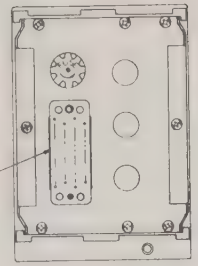

CR14
CR9
CR10
CR11
CR12
CR13
4
1
K6 COIL
K5 COIL
K1 COIL
K2 COIL
K3 COIL
K4 COIL
S4 (CALIB.)
S2 (MONITOR)
BAL
EXCIT
T1
CR1
CR2
1/4A SLO-BLO
+
−
SEE POWER SUPPLY SCHEMATIC DRAWING #4470.1-501C

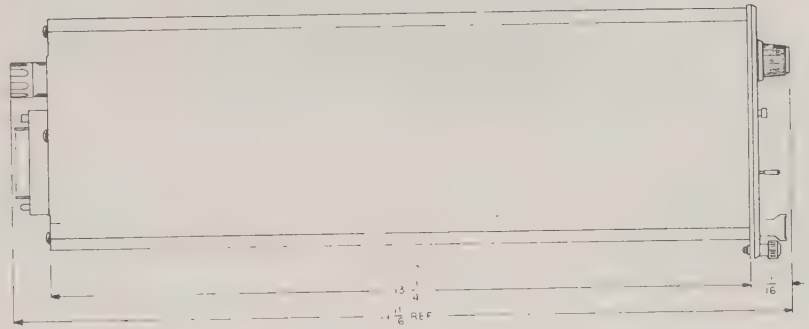


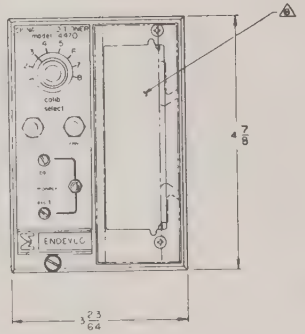
SCHEMATIC
MODEL 4470
SIGNAL CONDITIONING MODULE
6/69

		QPT
		1
		OPT
		OPT
		OPT
		OPT
		OPT
		OPT
		OPT

		RELEASED
		DELETED E/910 & E/915 ADDED 2903 & /2902
		ADDED /6A1 CARD CHARACTERIZATION







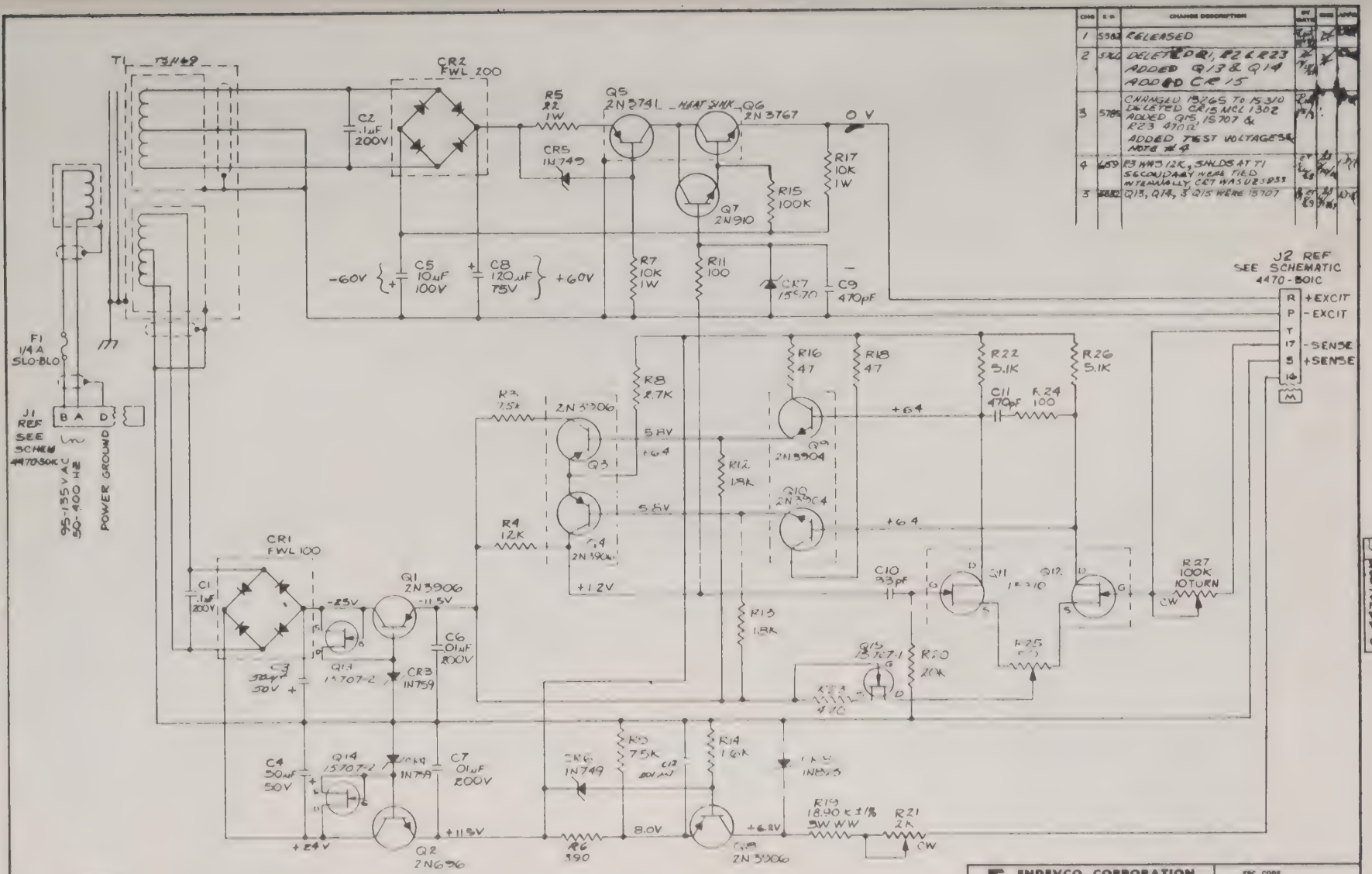
D-4470-C SHT 2 A

NOTES

1. THIS DRAWING SUBJECT TO FUTURE CHANGE WITHOUT NOTICE.
2. WHEN UNIT IS WIRED FOR 230V OPERATION, MODEL SERIAL PLATE WILL INDICATE MODEL 4470V
3. UNIT WEIGHT 6LBS.
4. EP908 MODDED CONNECTOR, SUPPLIED AT ADDITIONAL COST IF SPECIFIED ON ORDER.
5. FITS MODEL 4470 SIGNAL CONDITIONERS WILL FIT IN THE 4842 OR 49A3 RACK
6. PLUG-IN CARDS FURNISHED AS SEPARATE OPTIONAL ASSEMBLIES

ENDEVCO CORPORATION
Pasadena, California

SIGNAL CONDITIONER D 4470-C



CHG	E.O.	CHANGE DESCRIPTION	BY	DATE	APPD
1	5302	RELEASED			
2	5321	DELETED CR1, R2 & R23 ADDED Q13 & Q14 ADDED CR 15			
3	5784	CHANGED 1326S TO 15310 DELETED CR15 NCL 1302 ADDED Q15, 15707 & R23 47012 ADDED TEST VOLTAGES NOTE #4			
4	659	R3 WAS 12K, SHLDS AT T1 SECONDARY WERE TIED INTERNALLY, CKT WAS U25033			
5	5882	Q13, Q14, & Q15 WERE 15707			

NOTES:
1. ALL RESISTOR VALUES ARE IN OHMS ±5%, ½ W UNLESS OTHERWISE SPECIFIED.
2. COMPONENTS AS GIVEN OR THEIR EQUIVALENTS
3. THIS DRAWING SUBJECT TO FUTURE CHANGE WITHOUT NOTICE.
4. ALL VOLTAGES ARE MEASURED WITH RESPECT TO THE + SENSING LINE UNLESS OTHERWISE NOTED AND ARE NOMINAL BASED ON E_{LINE} = 115V, I_{OUT} = 0 & 0% COMPONENT TOLERANCE

ENDEVCO CORPORATION
Pasadena, California
FSC CODE 59411

SPECIFICATIONS UNLESS OTHERWISE NOTED
LIMITS OF DIMS: 1 BREAK ALL SHARP CORNERS .005 MAX. 2 SURFACE ROUGHNESS 63 MICROINCH .500 MAX. 3 DIAMETERS TO BE CONCENTRIC WITHIN .005 T.I.R. 4 FILLET RADIUS .010 MAX.
ANGULAR ±
FRACTIONAL ±
DECIMAL ±
SCALE: DO NOT SCALE DRAWING
MATERIAL:
FINISH:
DRAWN BY: Larry Hoffer 7-24-70
CHKD BY:
PROJ. ENG.:
PART NAME: SCHEMATIC
PRODUCT: DIAGRAM, POWER SUPPLY
4470
SIZE C
DWG NO. 4470-1-501C
CODE 5

C-4474-501C 5

IMPORTANT NOTICE: INFORMATION DISCLOSED BY THIS DRAWING IS ENDEVCO CONFIDENTIAL INFORMATION. REPRODUCTION, DUPLICATION, OR MANUFACTURING RIGHTS GRANTED BY WRITTEN PERMISSION ONLY

LIST OF MATERIALS

ITEM	PART NO	DESCRIPTION	QTY
1	SEE TABLE B	BASIC ASSEMBLY	1
2	2970-1	MODEL SERIAL PLATE	1
3	EW39	WIRE, BUS	A/R
4			
5	EHN75	NUT, HEX, 3-48	OPT
6			
7	ER866A	RESISTOR 3.3K ±5% ¼W	OPT
CR9	ECR182	DIODE IN457	OPT
CR10	↓	↓	↓
CR11			
CR12			
CR13			
CR14	ECR182	DIODE IN457	OPT
K1	EK51	RELAY	OPT
K2	↑	↑	↑
K3			
K4			
K5	EK51		
K6	EK52	RELAY	OPT

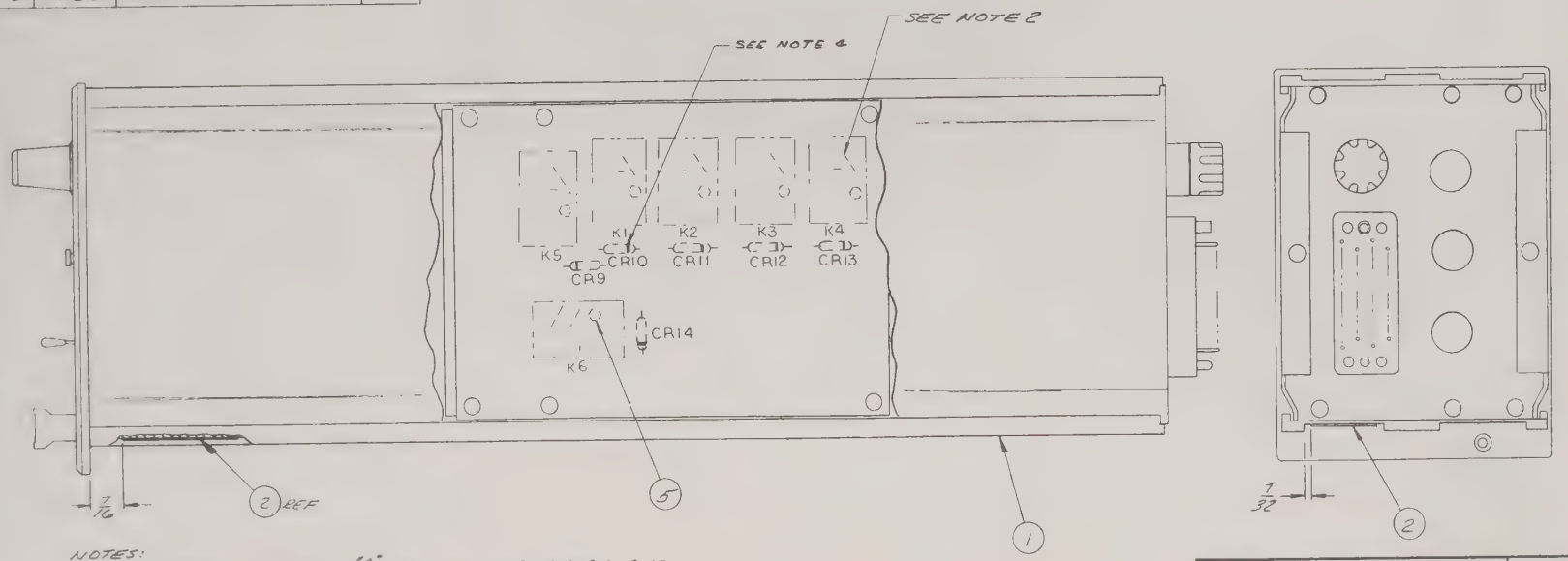
TABLE A

IDENT CODE	K1	K2	K3	K4	K5	K6	CR9	CR10	CR11	CR12	CR13	CR14	ITEM 5	ITEM 7
.000	—	—	—	—	—	—	—	—	—	—	—	—	—	6
.001	/							/					/	5
.002	/	/						/	/				2	4
.003	/	/	/					/	/	/			3	3
.004	/	/	/	/				/	/	/	/		4	2
.011	/				/		/	/					2	4
.012	/	/			/		/	/	/				3	3
.013	/	/	/		/		/	/	/	/			4	2
.014	/	/	/	/	/		/	/	/	/	/		5	1
.100						/						/	/	5
.101	/					/		/				/	2	4
.102	/	/				/		/	/			/	3	3
.103	/	/	/			/		/	/	/		/	4	2
.104	/	/	/	/		/		/	/	/	/	/	5	1
.111	/				/	/	/	/				/	3	3
.112	/	/			/	/	/	/	/			/	4	2
.113	/	/	/		/	/	/	/	/	/		/	5	1
.114	/	/	/	/	/	/	/	/	/	/	/	/	6	—

TABLE B

MODEL NO.	ITEM 1
4470.XXX	15303-1
4470.XXX-V	15303-2

CHG	E.O	CHANGE DESCRIPTION	BY DATE	CHK	APPR
1	5382	RELEASED	2/11/68		
2	5385	ADDED ⅞ DIM.	2/11/68		
3	5891	ADDED ITEM 7 REVISED NOTE 2	8/13/68		



NOTES:

1. REFER TO TABLE "A" FOR PROPER RELAY AND DIODE COMBINATION 3
2. WHEN ANY RELAY & DIODE COMBINATION IS OMITTED USE ITEM 3 TO JUMPER PIN 5 TO PIN 6 AND PIN 8 TO PIN 9. WHEN K6 IS OMITTED ALSO JUMPER PIN 11 TO PIN 12 & INSTALL ITEM 7 IN PLACE OF ANY DIODE OMITTED.
3. AFTER PROPER RELAY SELECTION HAS BEEN MADE MARK ITEM 2 WITH MODEL "4470.XXX" SUBSTITUTING IDENT CODE FOR XXX.
4. BAR INDICATES CATHODE END OF DIODE.

ENDEVCO CORPORATION
Pasadena, California

FSC CODE 95411

SPECIFICATIONS UNLESS OTHERWISE NOTED

LIMITS OF DIMS.
ANGULAR ± —
FRACTIONAL ± 1/16
DECIMAL ± —

1. BREAK ALL SHARP CORNERS .005 MAX.
2. SURFACE ROUGHNESS 63 MICROINCH RMS MAX.
3. DIAMETERS TO BE CONCENTRIC WITHIN .005 T.I.R.
4. FILLET RADIUS .010 MAX

SCALE 1/1 — DO NOT SCALE DRAWING
MATERIAL LISTED — DRAWN BY M.L. Tate 7/16/68
FINISH — CHKD BY
PROJ. ENG

4470 PRODUCT

PART NAME: MAIN ASSEMBLY

SIZE C — DWG. NO. 4470.XXX-1C — CHG 3

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C-4470.XXX-1C 3

12/68 DIETERICH-POST CLEARPRINT 1000M-10

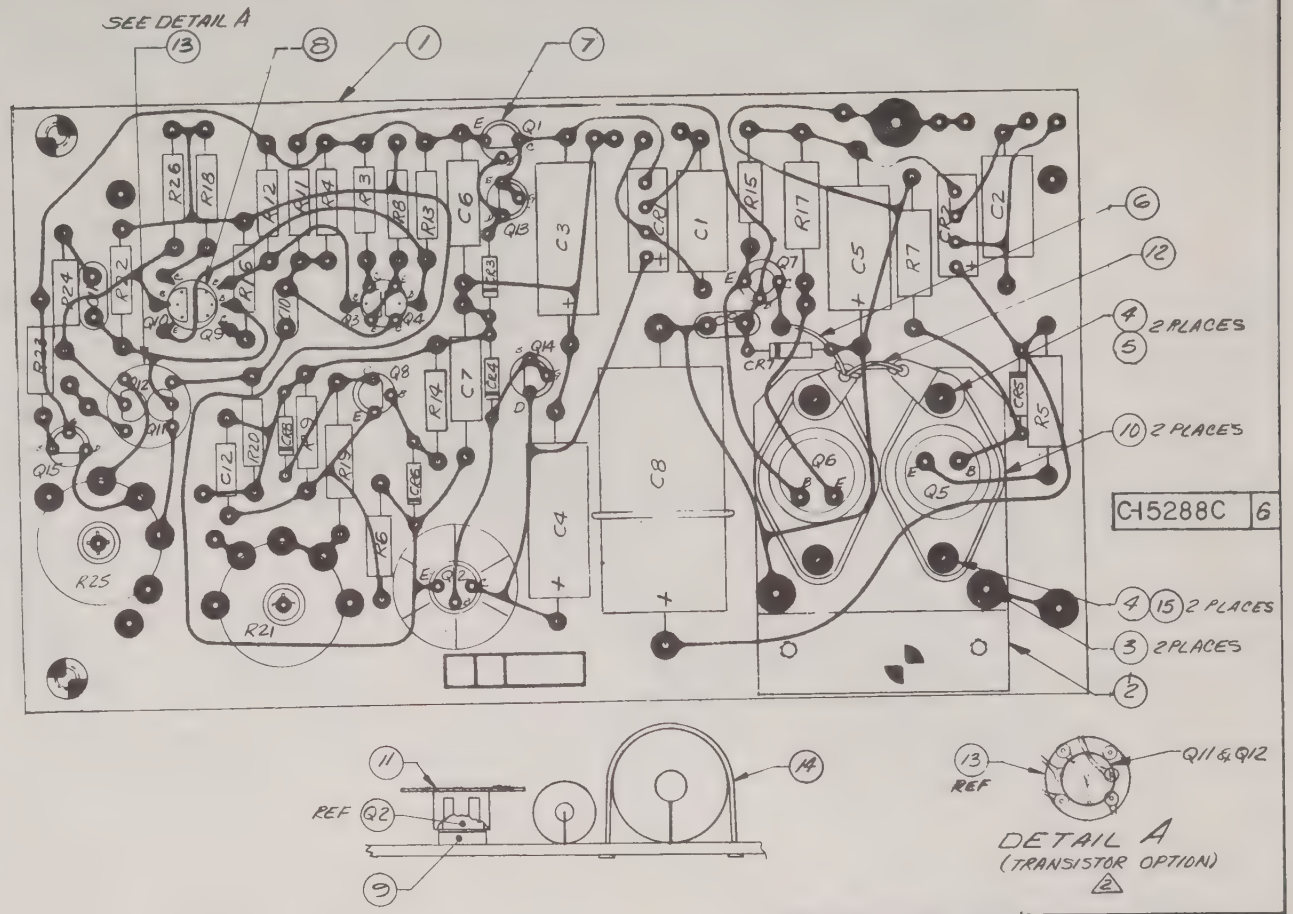
LIST OF MATERIALS

	PART NO.	DESCRIPTION	QTY
1	15287	CIRCUIT BOARD	1
2	15282	HEAT SINK	1
3	EH917	SCREW, MACH #4-40 X 1/4	2
4	EH912	SCREW, INSUL #6-32 X 3/8	4
5	EHL5	LUG, LOCKWASHER	2
6	EW32	WIRE, BLACK	A/R
7	EHW108	TRANSIPAD	6
8	EHW182	TRANSIPAD	2
9	EHW94	TRANSIPAD	1
10	EHW176	INSULATOR, MICA	2
11	EHM283	HEAT DISSIPATOR	1
12	EW39	BUS WIRE, AWG 22	A/R
13	EHW102	SPACER, TRANSISTOR	1
14	EHF88	STRAP, RUBBER	1
15	EHW172	LOCKWASHER, #6	2
C1	EC469	CAPACITOR, .1uF, 200V	1
C2	EC469	.1uF, 200V	1
C3	EC347	50uF, 50V	1
C4	EC347	50uF, 50V	1
C5	EC602	10uF, 100V	1
C6	EC166	.01uF, 200V	1
C7	EC186	.01uF, 200V	1
C8	T3043	120uF, 75V	1
C9	EC224	470pF	1
C10	EC107	33pF	1
C11	EC224	470pF	1
C12	EC180	CAPACITOR, .001uF	1
CR1	ECR102	DIODE, FWL100	1
CR2	ECR99	FWL200	1
CR3	ECR121A	1N759	1
CR4	ECR121A	1N759	1
CR5	ECR60	1N749	1
CR6	ECR80	1N749	1
CR7	15970		1
CR8	ECR137	DIODE, 1N825	1
Q1	EQ127	TRANSISTOR, 2N3906	1
Q2	EQ83	2N696	1
Q3	EQ127	2N3906	1
Q4	EQ127	2N3906	1
Q5	EQ155	2N3741	1
Q6	EQ154	2N3767	1
Q7	EQ52A	2N910	1
Q8	EQ127	2N3906	1
Q9	EQ130	2N3904	1
Q10	EQ130	2N3904	1
Q11	15310	MATCHED PAIR	1 PR
Q12	15310	MATCHED PAIR	
Q13	15707-2	FET	1
Q14	15707-2	FET	1
Q15	15707-1	TRANSISTOR, FET	1
R1			
R2			
R3	ER710	RESISTOR, 7.5K	1
R4	ER249	12K	1
R5	ER1344	22Ω, 1W	1
R6	ER184	390Ω	1
R7	ER903	10K, 1W	1
R8	ER107	2.7K	1
R9	ER710	7.5K	1
R10			
R11	ER171	RESISTOR, 100Ω	1

R12	ER225	RESISTOR, 18K	1
R13	ER225	18K	1
R14	ER1023	1.6K	1
R15	ER233	100K	1
R16	ER824	47Ω	1
R17	ER903	10K, 1W	1
R18	ER824	47Ω	1
R19	ER1754	RESISTOR, 18.90K, 3W, W.W.	1

R20	ER671	RESISTOR, 20K	1
R21	ER1009	POTENTIOMETER, 2K	1
R22	ER2005	RESISTOR, 5.1K (MAY BE PAIR) (SEE R26)	1PR
R23	ER156	RESISTOR, 470Ω	1
R24	ER171	RESISTOR, 100Ω	1
R25	ER1697	POTENTIOMETER, 50Ω	1
R26	ER2005	RESISTOR, 5.1K	—

CHG	E O	CHANGE DESCRIPTION	BY DATE	CHK'D	APPD
2	5786	REVISED & REDRAWN	EET 2/28/67	MJ	DMC
3	5894	ADDED NOTE 4 ADDED POLARITY TO C8, C12, C83, REVERSED Q1	AS 3/6/67	MJ	
4	6159	ADDED ITEM 15, R2 WAS 249, 12K. REVISED CIRCUITRY, CKT WAS ECR169, U25833.	EET 4/11/67	MJ	DMC
5	6246	R22 & R26 WERE ER763	EET 4/20/67	MJ	DMC
6.	6682	Q13, Q14 & Q15 WERE 15707	AS 7/11/67	MJ	DMC



NOTES:

(1) APPLY THERMAL JOINT COMPOUND NO. 15065 AT Q5 AND Q6.

(2) TRANSISTORS Q11 AND Q12 MAY BE SUPPLIED IN A TO5, TO18 OR TWO TO92 CASES. WHEN SUPPLIED IN TO92 CASE CONFIGURATION, INSTALL AS SHOWN. REFER TO DETAIL "A" FOR INSTALLATION OF TO5 OR TO18 CASE.

(3) CIRCUITRY SHOWN IS ON FAR SIDE OF BOARD

(4) LEAD SPACING OF ALL 1/2W COMPOSITION RESISTORS IS .700.

ENDEVCO CORPORATION Pasadena, California — FSC CODE 95411

SPECIFICATIONS UNLESS OTHERWISE NOTED

LIMITS OF DIMS: ANGULAR ±—, FRACTIONAL ±—, DECIMAL ±—

1 BREAK ALL SHARP CORNERS .005 MAX.
2 SURFACE ROUGHNESS 63 MICROINCH RMS MAX.
3 DIAMETERS TO BE CONCENTRIC WITHIN .005 T I R
4 FILLET RADIUS .010 MAX

SCALE 2/1 — DO NOT SCALE DRAWING

MATERIAL LISTED — DRAWN BY EET 2/28/67

FINISH — CHK'D BY MJ

PROJ ENG DMC

4470 PRODUCT

PART NAME POWER SUPPLY CIRCUIT BOARD ASSEMBLY

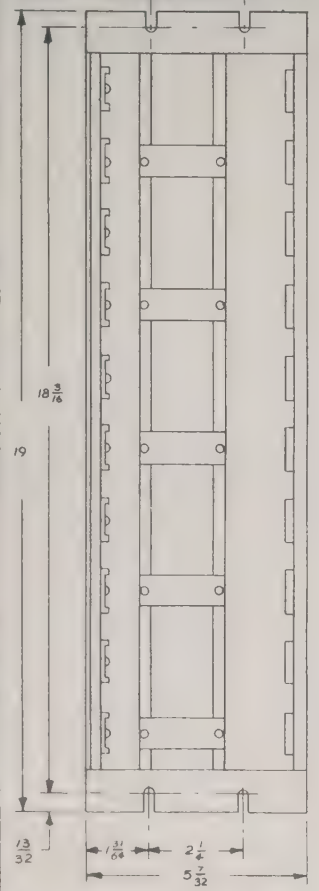
SIZE C — DWG. NO. 15288C — REV 6

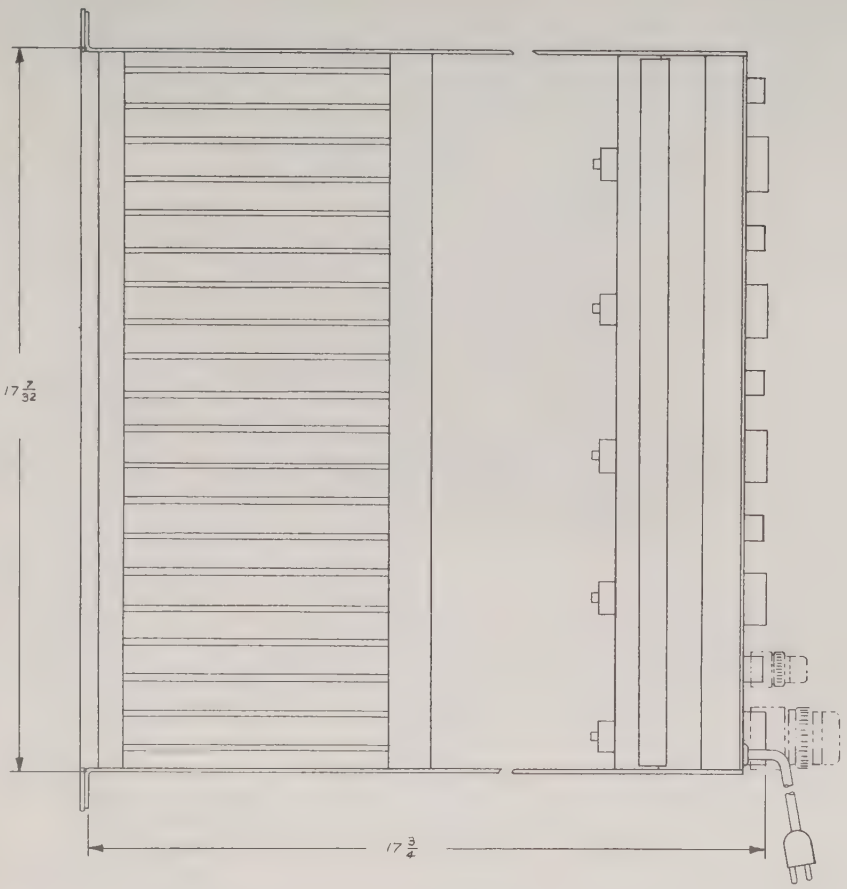
IMPORTANT NOTICE: INFORMATION DISCLOSED BY THIS DRAWING IS ENDEVCO CONFIDENTIAL RE-PRODUCTION DUPLICATION OR MANUFACTURING RIGHTS GRANTED BY WRITTEN PERMISSION ONLY

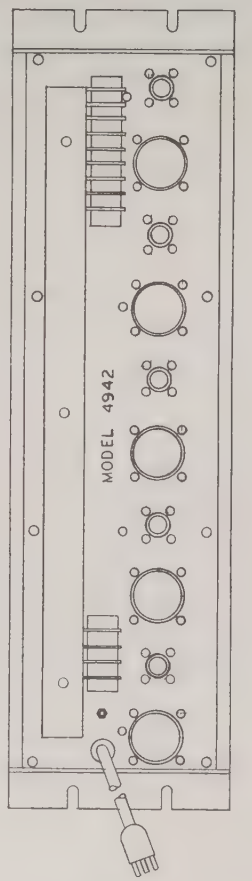
LIST OF MATERIALS

PART NO	DESCRIPTION	QTY
4942	RACK	1
14769	HARDWARE MTG KIT	1
13835	BLANK PANEL ASSEMBLY	6PT
EP186	CONNECTOR MS3106A10SL-3S	5
EHF88	CLAMP, CABLE MS3057-4	5
EP134	CONNECTOR MS3106A20-27P	5
EHF59	CLAMP, CABLE MS3057-12	5

CHG	E.O.	CHANGE DESCRIPTION	BY DATE	CHK	APPR
1	5586	RELEASED	10/12/67 MS		







C-4942-C | 1

NOTES:

1. IF UNIT IS WIRED FOR 230 VOLT OPERATION, NAMEPLATE WILL CARRY MODEL NO. 4942V AND POWER CORD WILL BE PIG-TAILED.
2. FIVE MODEL 4470 SIGNAL CONDITIONERS WILL FIT IN INSTRUMENT RACK MODEL 4942.
3. THIS DRAWING IS SUBJECT TO FUTURE CHANGE WITHOUT NOTICE.

ENDEVCO CORPORATION
Pasadena, California

FSC CODE 95411

SPECIFICATIONS UNLESS OTHERWISE NOTED

LIMITS OF DIMS.		1. BREAK ALL SHARP CORNERS .005 MAX.
ANGULAR	± —	2. SURFACE ROUGHNESS 63 MICROINCH RMS MAX.
FRACTIONAL	± 1/32	3. DIAMETERS TO BE CONCENTRIC WITHIN .005 T.I.R.
DECIMAL	± —	4. FILLET RADIUS .010 MAX.

SCALE 1/2 — DO NOT SCALE DRAWING

MATERIAL: LISTED — DRAWN BY MS 10/12/67

FINISH: — CHKD BY [illegible] 10/12/67

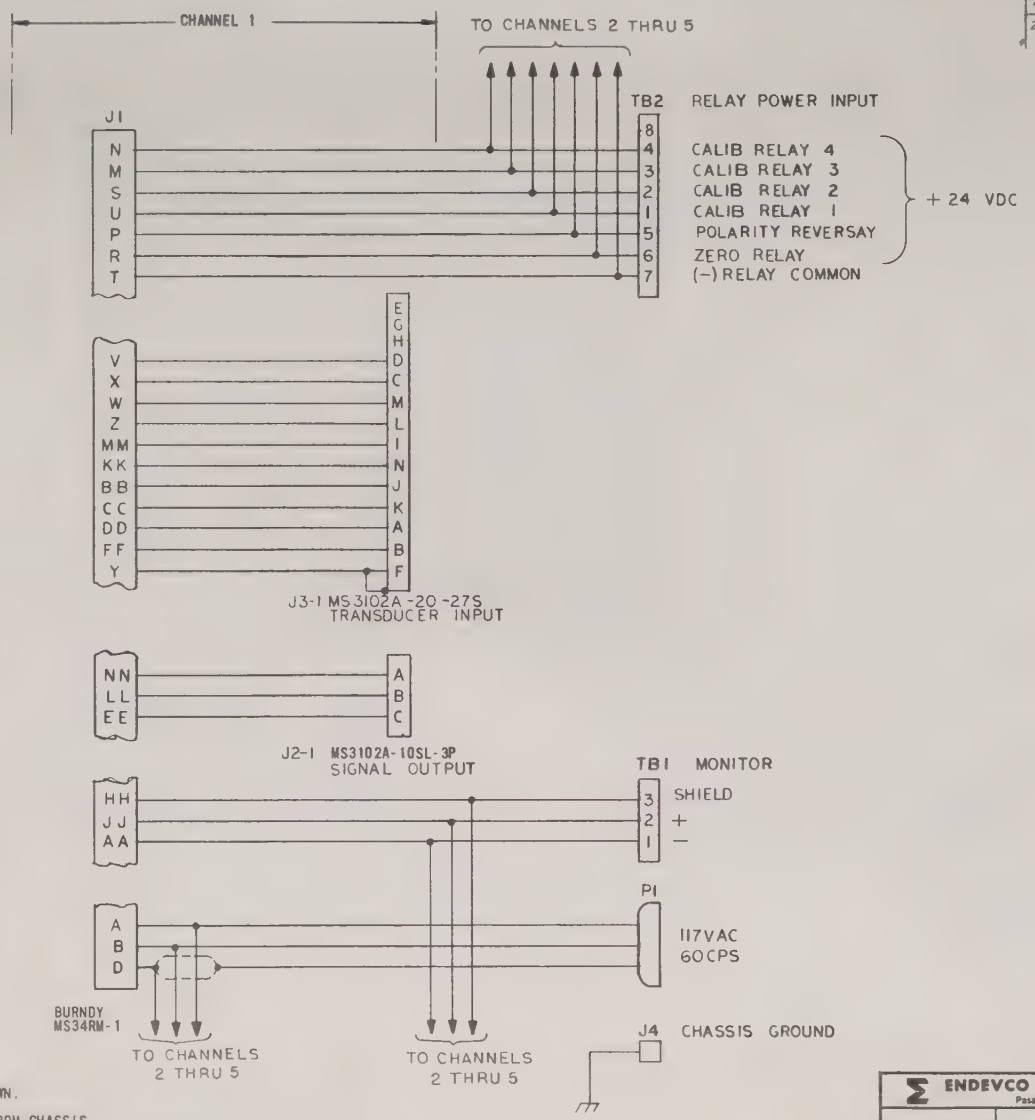
PROJ ENG [illegible]

PART NAME: RACK — SIZE C — DWG NO 4942-C — CHG 1

PRODUCT

12/86 DIETERICH-POST CLEARPRINT 300M-30

CHG	E.O	CHANGE DESCRIPTION	BY DATE	CHK	APPR
1	5390	RELEASED			
2	5807	ON J1 "KK" VIAS W/			



C-4942-501C | 2

NOTES:

1. ONE OF 5 TYPICAL CIRCUITS SHOWN.
2. ALL CONNECTORS ARE FLOATING FROM CHASSIS.
3. FOR 230 VOLT OPERATION, MODEL-SERIAL PLATE WILL CARRY 4942V & POWER CORD WILL BE PIG-TAILED.
4. THIS DRAWING IS SUBJECT TO FUTURE CHANGE WITHOUT NOTICE.

ENDEVCO CORPORATION
Pasadena, California

FSC CODE 95411

SPECIFICATIONS UNLESS OTHERWISE NOTED

LIMITS OF DIMS
ANGULAR ± —
FRACTIONAL ± —
DECIMAL ± —

1. BREAK ALL SHARP CORNERS .005 MAX
2. SURFACE ROUGHNESS 63 MICROINCH RMS MAX.
3. DIAMETERS TO BE CONCENTRIC WITHIN .005 T.I.R
4. FILLET RADIUS .010 MAX

SCALE —
DO NOT SCALE DRAWING
MATERIAL —
DRAWN BY
CHKD BY
FINISH. —
PROJ. ENG.

4942
PRODUCT

PART NAME
SCHEMATIC DIAGRAM

SIZE C | DWG. NO. 4942-501C | CHG 2

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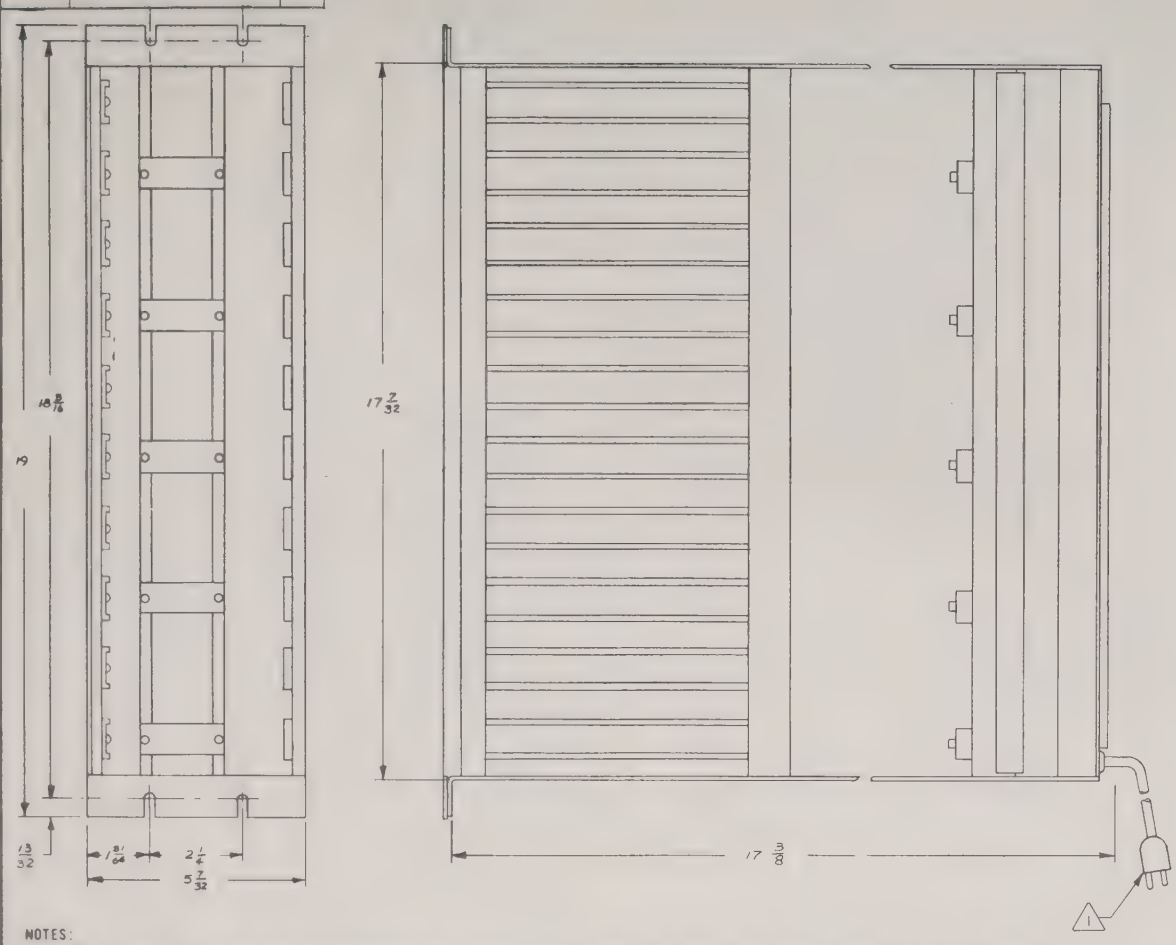
12/85 DIETERICH-POST CLEARPRINT 208M-10

LIST OF MATERIALS		
PART NO	DESCRIPTION	QTY
4943	RACK	1
14769	HARDWARE MTG KIT	1
13835	BLANK PANEL ASSEMBLY	OPT
EE125	SOCKET, CRIMP (BURNDY YC2CM-L)	75

CHG	E.O	CHANGE DESCRIPTION	BY DATE	CHK	APPR
1	6013	RELEASED	MS 4/14/68	JT	BWC
2	6098	ADDED NOTE 4 & BURNDY # TO L/M.	JT 4/16/68	JT	BWC



C 4943-C 2

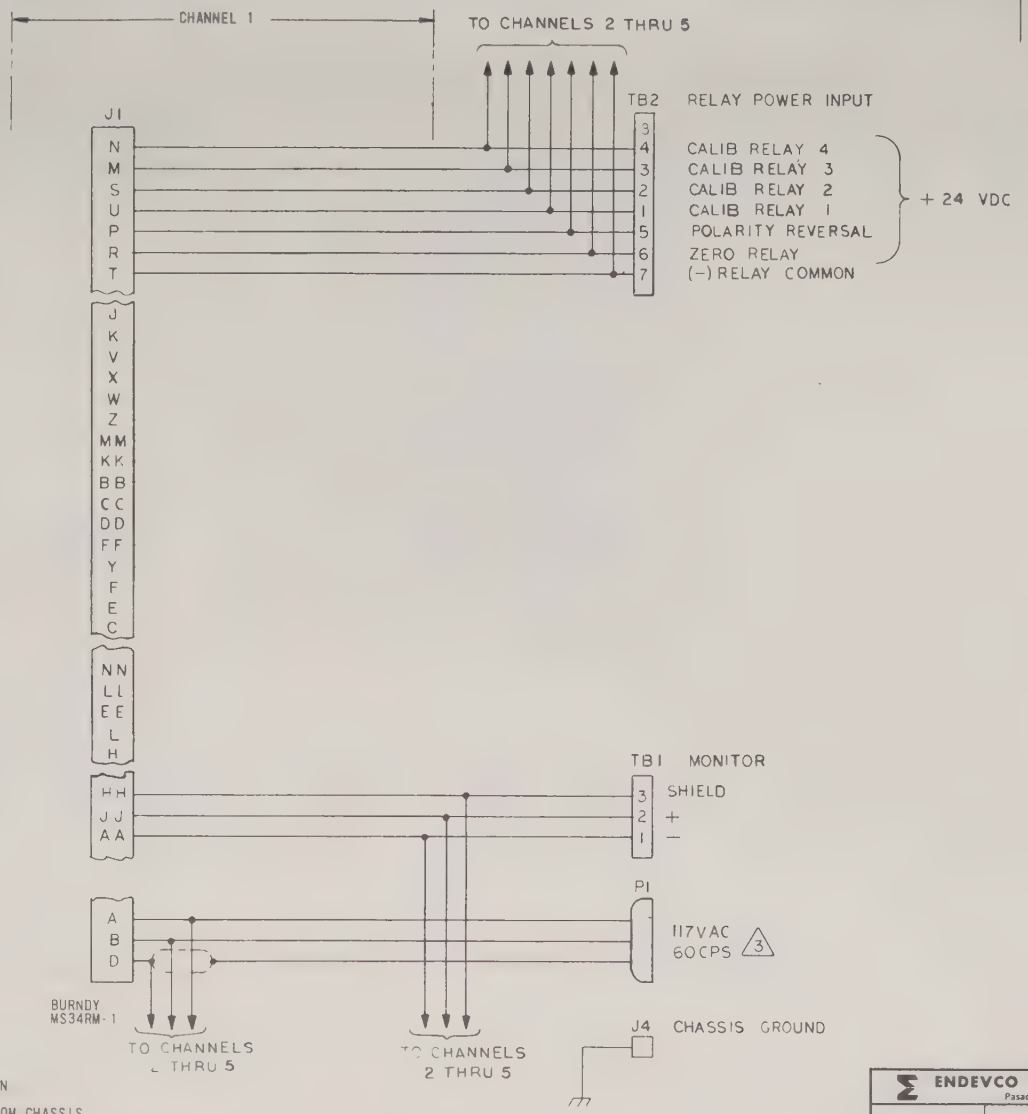
NOTES:

1. IF UNIT IS WIRED FOR 230 VOLT OPERATION, NAMEPLATE WILL CARRY MODEL NO 4943V AND POWER CORD WILL BE PIG TAILED
2. FIVE MODEL 4470 SIGNAL CONDITIONERS WILL FIT IN INSTRUMENT RACK MODEL 4943.
3. THIS DRAWING IS SUBJECT TO FUTURE CHANGE WITHOUT NOTICE.
4. CRIMP TOOL FOR EE125 NOT SUPPLIED.

ENDEVCO CORPORATION, Pasadena, California	FSC CODE 95411	
SPECIFICATIONS UNLESS OTHERWISE NOTED		
LIMITS OF DIMS: ANGULAR ±, FRACTIONAL ±1/32, DECIMAL ±, SCALE 1/2	1. BREAK ALL SHARP CORNERS .005 MAX. 2. SURFACE ROUGHNESS 63 MICROINCH RMS MAX. 3. DIAMETERS TO BE CONCENTRIC WITHIN .005 T.I.R. 4. FILLET RADIUS .010 MAX	DO NOT SCALE DRAWING
MATERIAL: LISTED		DRAWN BY MLS 3-12-68
FINISH		CHKD BY JT 4/16/68
		PROJ ENG BWC
PART NAME: RACK		SIZE C, DWG NO 4943-C, CHG 2
PRODUCT		

11/66 DIETERICH-POST CLEARPRINT 1000H-10

CHG	E.O.	CHANGE DESCRIPTION	BY DATE	CHK	APPR
1	6013	RELEASED	JHS 4/4/68	JF	ADM



C 4943-501C | 1

NOTES:

1. ONE OF 5 TYPICAL CIRCUITS SHOWN
2. ALL CONNECTORS ARE FLOATING FROM CHASSIS
3. FOR 230 VOLT OPERATION, MODEL-SERIAL PLATE WILL CARRY 4943V & POWER CORD WILL BE PIG-TAILED.
4. THIS DRAWING IS SUBJECT TO FUTURE CHANGE WITHOUT NOTICE.

ENDEVCO CORPORATION
Pasadena, California

FSC CODE 95411

SPECIFICATIONS UNLESS OTHERWISE NOTED

LIMITS OF DIMS
ANGULAR ° —
FRACTIONAL ± —
DECIMAL ± —

1. BREAK ALL SHARP CORNERS .005 MAX. *
2. SURFACE ROUGHNESS 63 MICROINCH RMS MAX.
3. DIAMETERS TO BE CONCENTRIC WITHIN .005 T.I.R.
4. FILLET RADIUS .010 MAX.

SCALE. —— DO NOT SCALE DRAWING

MATERIAL ——
FINISH ——

DRAWN BY MLS 4-12-68
CHKD BY JF 4-14-68
PROJ. ENG. ADM

PRODUCT	PART NAME	SIZE	DWG NO.	CHG
4943	SCHEMATIC DIAGRAM	C	4943-501C	1

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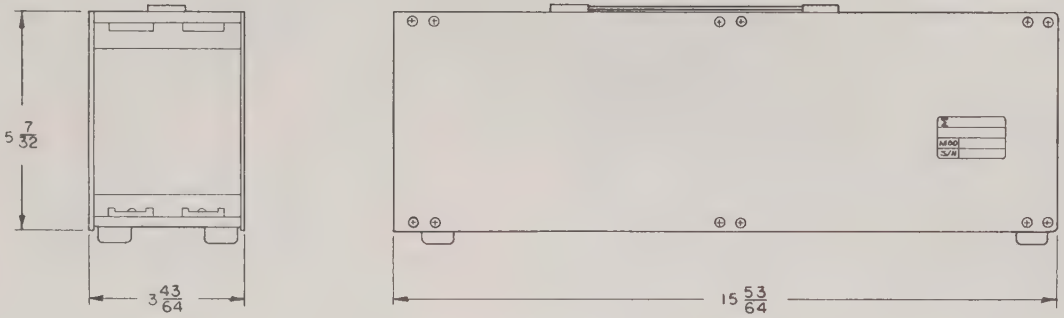
12/66 DIETERICH-POST CLEARPRINT 1000M 10

LIST OF MATERIALS		
PART NO	DESCRIPTION	QTY
2993	CARRYING CASE	1
15769	CONVENIENCE CABLE	OPT

CHG	E.O.	CHANGE DESCRIPTION	BY DATE	CHK	APPR
1	6011	RELEASED	MCS 3/4/68		



C 2993-C | 1

NOTES:

(1) CARRYING CASE WILL ACCOMMODATE ONE MODEL 4470 SIGNAL CONDITIONER.

(2) THIS DRAWING IS SUBJECT TO FUTURE CHANGE WITHOUT NOTICE.

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FSC CODE 15411

SPECIFICATIONS UNLESS OTHERWISE NOTED

LIMITS OF DIMS.
ANGULAR ± —
FRACTIONAL ± 1/64
DECIMAL ± —

1. BREAK ALL SHARP CORNERS .008 MAX.
2. SURFACE ROUGHNESS 63 MICROINCH RMS MAX.
3. DIAMETERS TO BE CONCENTRIC WITHIN .005 T.I.R.
4. FILLET RADIUS .010 MAX.

SCALE 1/2 — DO NOT SCALE DRAWING

MATERIAL: —
FINISH: —

DRAWN BY MCS 3/8/68
CHKD BY
PROJ ENG:

PRODUCT
PART NAME: CARRYING CASE
SIZE C | DWG. NO. 2993-C | CHG 1

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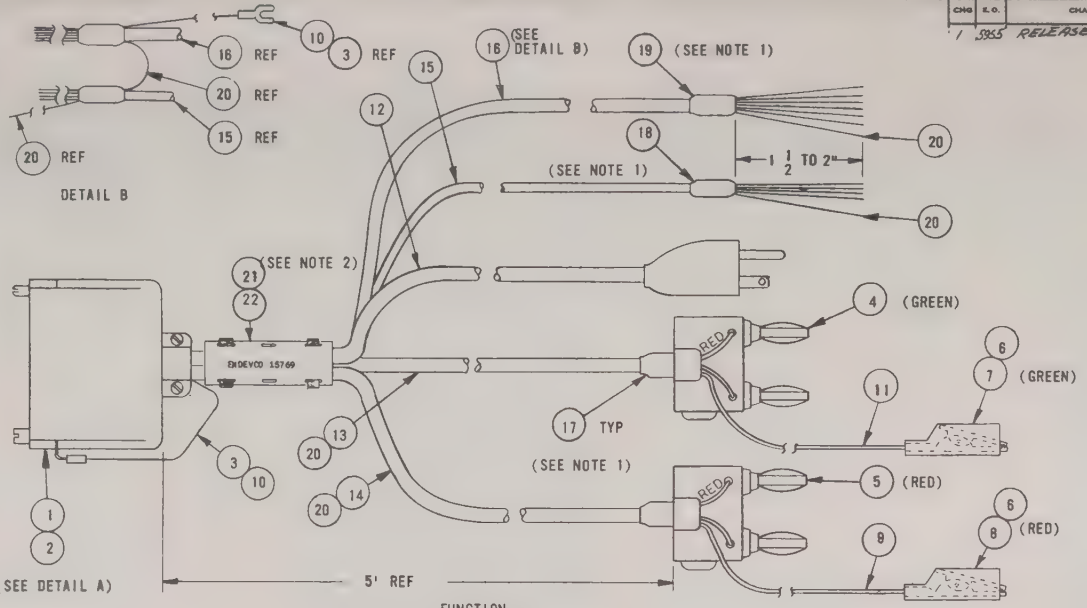
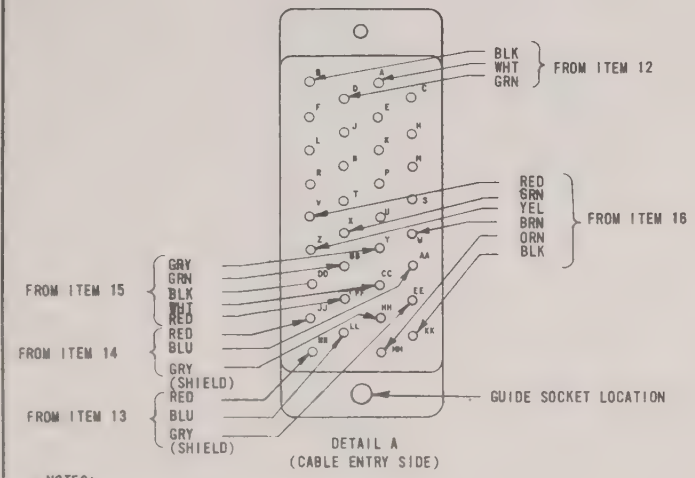
LIST OF MATERIALS

ITEM	PART NO.	DESCRIPTION	QTY
1	EP245	HOODED CONNECTOR COMBINATION	1
2	EE125	CONTACT - SOCKET	20
3	EE69	TERMINAL, SOLDERLESS	1
4	EP247	PLUG, DOUBLE BANANA - GREEN	1
5	EP248	PLUG, DOUBLE BANANA - RED	1
6	EHF86	ALLIGATOR CLIP	2
7	EHR37	ALLIGATOR CLIP BOOT (GREEN)	1
8	EHR38	ALLIGATOR CLIP BOOT (RED)	1
9	EW34	WIRE, RED	6"
10	EW36	WIRE, GRY	4"
11	EW37	WIRE, GRN	6"
12	EW51	POWER CORD	1
13	EW196	CABLE, SHIELDED, 2 COND.	5'
14	EW196	CABLE, SHIELDED, 2 COND.	5'
15	EW306	CABLE, SHIELDED, 4 COND.	5'
16	EW320	CABLE, SHIELDED, 6 COND.	5'
17	EW219	FERRULE	4
18	EW318	FERRULE	2
19	EW321	FERRULE	2
20	EW36	WIRE, GRY, 2"	6
21	EW456	IDENTIFICATION PLATE	1
22	EW403	HARNESS TIE	2
23			
24			
25			
26			

CHG	E.O.	CHANGE DESCRIPTION	BY DATE	CHK	APPR
1	5955	RELEASED	5/14/69		

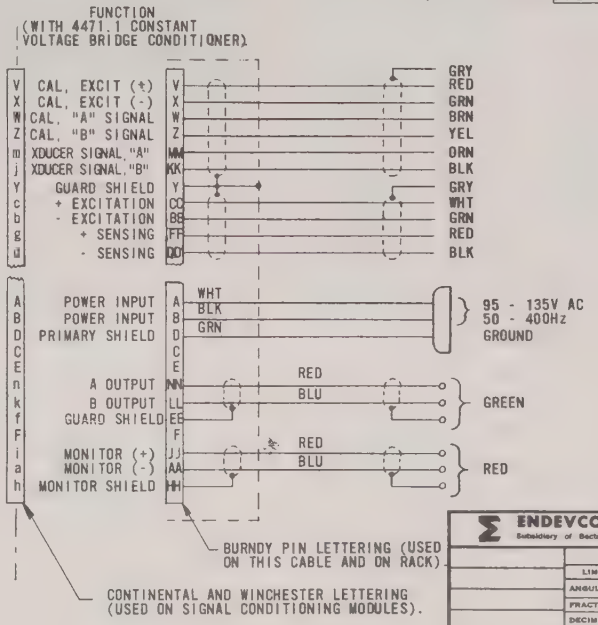




NOTES:

(1) DILATE STRIPPED SLEEVING AND REPLACE OVER CABLE ENDS.

(2) HOT STAMP ITEM 21 WITH "ENDEVCO 15769".


FUNCTION
(WITH 4471.1 CONSTANT
VOLTAGE BRIDGE CONDITIONER)
V CAL, EXCIT (+) V GRY
X CAL, EXCIT (-) X RED
W CAL, "A" SIGNAL W GRN
Z CAL, "B" SIGNAL Z BRN
m XDUCER SIGNAL,"A" MM YEL
j XDUCER SIGNAL,"B" KK ORN
Y GUARD SHIELD Y BLK
c + EXCITATION CC GRY
b - EXCITATION BB WHT
g + SENSING FF GRN
u - SENSING DD RED
BLK
A POWER INPUT A WHT
B POWER INPUT B BLK
D PRIMARY SHIELD D GRN
95 - 135V AC
50 - 400Hz
GROUND
E
n A OUTPUT NN RED
k B OUTPUT LL BLU
f GUIDE SHIELD EE GREEN
F
i MONITOR (+) JJ RED
a MONITOR (-) AA BLU
h MONITOR SHIELD HH RED
BURNDY PIN LETTERING (USED ON THIS CABLE AND ON RACK)
CONTINENTAL AND WINCHESTER LETTERING (USED ON SIGNAL CONDITIONING MODULES).

C 15769C CHG 1

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FSC CODE 95411

SPECIFICATIONS UNLESS OTHERWISE NOTED

LIMITS OF DIMS.
ANGULAR ±
FRACTIONAL ± —
DECIMAL ± —
1. BREAK ALL SHARP CORNERS .005 MAX.
2. SURFACE ROUGHNESS 63 MICROINCH RMS MAX.
3. DIAMETERS TO BE CONCENTRIC WITHIN .005 T.I.R.
4. FILLET RADIUS .010 MAX.
SCALE —— DO NOT SCALE DRAWING

MATERIAL: SEE L/M
FINISH: ——
DRAWN BY G.S. 3-25-69
CHKD BY [illegible] 3-25-68
PROJ. ENG. [illegible]

4470 PRODUCT
PART NAME: CONVENIENCE CABLE
SIZE C DWG. NO. 15769C CHG 1

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599

PARASITIC NOISE CURRENTS IN INSTRUMENT POWER SUPPLIES

The instrument power supply represents the engineers' effort to replace batteries with a more satisfactory source of DC power. The battery is less than an ideal power source and requires periodic replacement or recharging. The instrument power supply can be made as near to ideal as is necessary, but generally suffers from one handicap which is seldom encountered with the use of batteries. The problem is one of capacitive coupling to other elements of the system - primarily to the power line and to ground.

The over-all design of an instrument power supply is oriented to meet all of the excitation requirements imposed by given types of transducers. Of particular interest is the transducer circuit which has a four arm resistive bridge configuration such as is often used with strain gages. The methods of use of this transducer type often allow the subject parasitic capacities to force noise currents through the transducer, resulting in transducer voltages that are indistinguishable from data by the remainder of the system. This does not imply that only four arm bridges are subject to the effects of noise current. It does imply that the effect is circuit oriented and that the common usage of the four arm bridge makes it an ideal subject for study.

Transformer Primary Noise Currents

A close look at the primary-to-secondary capacitance will help to explain the mechanism behind noise currents. The transformer in Figure 1 is unshielded and has a distributed primary-to-secondary capacitance which can be represented by small capacitors from every loop of the primary winding to every loop of the secondary winding. The net result is that if the capacitance voltage relationship is unbalanced, then a net current (I) will circulate.

Figure 1 shows one side of the primary grounded. The reality that power lines are neither so definite nor so clean as this helps to make rigorous analysis complex; in addition, quantitative analysis of unshielded transformers requires precise knowledge of the transformer construction. For our purposes it is sufficient to demonstrate that noise currents exist and are dependent upon what are normally considered as parasitic parameters.

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TWX 910 588 3272 CABLE ENDEVCO

Transformer Primary Noise Currents (continued)

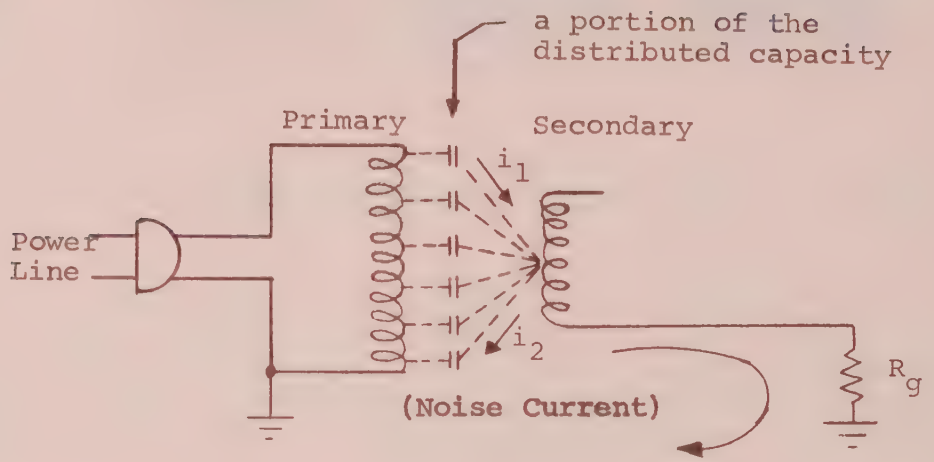


FIGURE 1.

It is important to note that if the secondary is grounded through an impedance then the noise current will flow through this impedance and will cause a noise voltage. When a substantial impedance is located between the power supply and ground, then the supply is said to be "floating." If, for example, a power supply terminal of a four arm bridge system is grounded then the noise current is shunted directly to ground without affecting the bridge output. If, instead, an output terminal of the same bridge system is grounded then the power supply is forced to "float" and the noise current will affect the bridge output. The effective resistance between the power supply output and ground is symbolized by R_g in this paper.

Reduction of noise currents in instrument power supplies to satisfactory levels is accomplished through the use of one or more internal shields. The designer, in his choice of a shielding system, generally does not eliminate the noise currents but rather forces them to circulate in a loop which does not include the load. It is most important, therefore, to follow the manufacturer's recommendations in connecting the shields to the instrumentation system, otherwise maximum benefit will not be obtained.

The Complete Power Supply and Its Application

There are six power supply terminals available to the user (eight terminals if external sensing is available). Of these, the use of the output terminals and power line terminals is obvious. The primary shield terminal carries fairly heavy circulating leakage currents and is best grounded at a point where these currents can most easily return to the power line without flowing through low level signal circuitry. Especially in larger systems, the

The Complete Power Supply and Its Application (continued)

total aggregate of primary shield currents can cause distressing noise problems if allowed to circulate through the system (low level signal) common buss. The guard shield is connected to the system common buss and services to prevent noise pickup and common mode currents. The latter will be expanded upon in some detail later.

The power supply as applied to a four arm strain gage channel is shown in Figure 2. The power supply in this example is "floating"; i.e., there is no direct (zero impedance) connection to ground. The ground to system common connection does not necessarily imply that there is no voltage between these two points; in general, a voltage will exist and may exceed a volt peak-to-peak in the larger systems.

Typical noise currents have been added to the schematic to give the reader a feeling for their magnitude. The values reflect current levels often encountered when using single channel instrument power supplies in the 0.5 to 5 watt range.

The Manifestation of Noise Current

The nature of how the noise current flows through the load and its effect upon data needs more detailed explanation. Since the noise currents are caused by quite small parasitic capacitors, the source impedance is very high, and the current appears to be supplied by a current generator. In other words, normal variations in values of loading do not affect the magnitude of the current and the noise voltage is defined by:

$$E_n = I_n R_g$$

where I_n is a fixed value for a given supply and R_g is the effective resistance to ground.

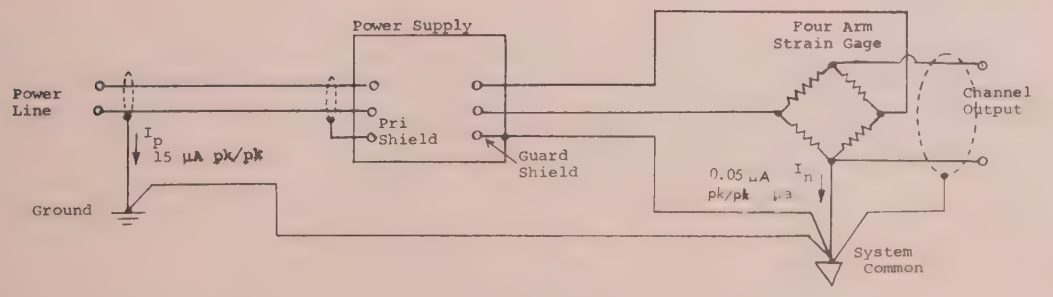


FIGURE 2.

The Manifestation of Noise Current (continued)

A synthesis of the power supply is shown in Figure 3, where the noise current generator has the value I_n. Figure 4 connects the power supply to a four arm bridge and includes the possible power supply output resistance.

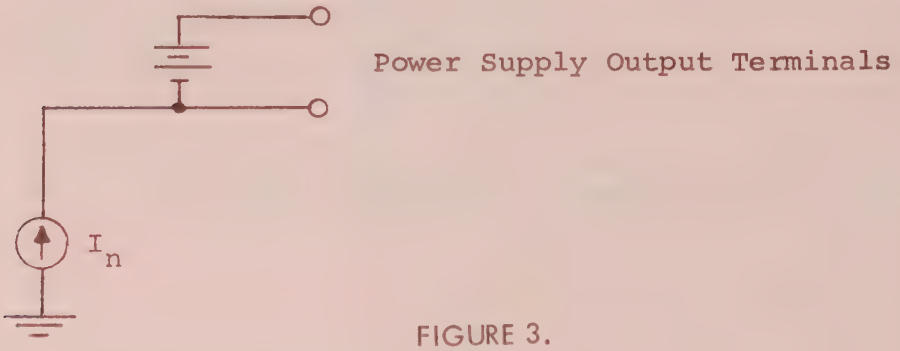


FIGURE 3.

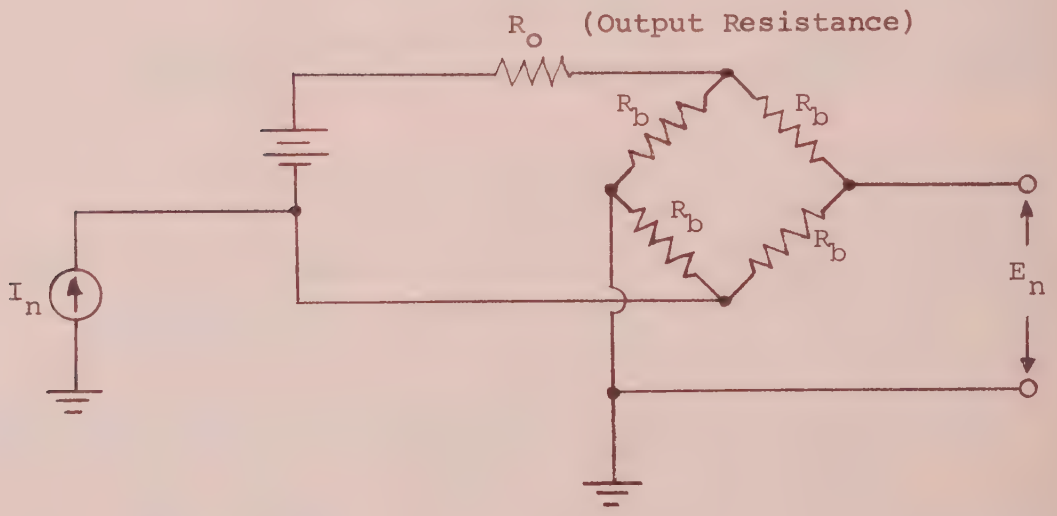


FIGURE 4.

The Manifestation of Noise Current (continued)

Since the battery in Figure 4 is a short circuit to I_n the circuit becomes:

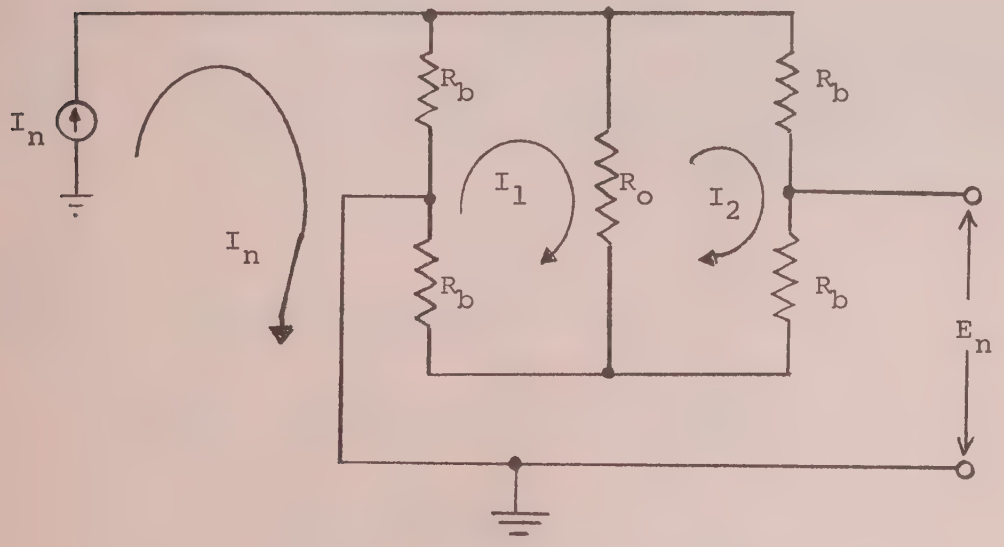


FIGURE 5.

The equations are:

Equation 1 $\quad E_n = I_1 R_b + I_2 R_b = (I_1 + I_2) R_b$

Equation 2 $\quad I_1 (2R_b + R_o) - I_2 R_o - I_n R_b = 0$

Equation 3 $\quad I_2 (2R_b + R_o) - I_1 R_o = 0$

Combining the equations results in:

$$E_n = 1/2\ I_n R_b$$

The results of this calculation give us two important pieces of information. First, the effect of noise current is independent of the power supply output impedance so that the net result will be the same if the power supply is either constant voltage or constant current. Secondly, the noise generated by the supply operating into a four equal arm bridge is described by the equation:

$$E_n = 1/2\ I_n R_b$$

where I_n is the supply noise current and R_b is the resistance of one arm of the bridge. (Since $E_n = I_n R_g$, then $R_g = 1/2\ R_b$ for a four equal arm bridge.)

The Manifestation of Noise Current (continued)

There is no preferred grounded side to a constant voltage power supply. The low output impedance allows the leakage current to be available from either output terminal with equal ease. The converse is true for the constant current power supply since it is unable to distinguish between its own output current and the noise current. If the constant current supply is grounded in such a manner as to force the noise current to flow through both the load and the current sensing element, then the noise will be a minimum. In this configuration, the power supply can sense the noise current through the load and correct its output by a corresponding amount.

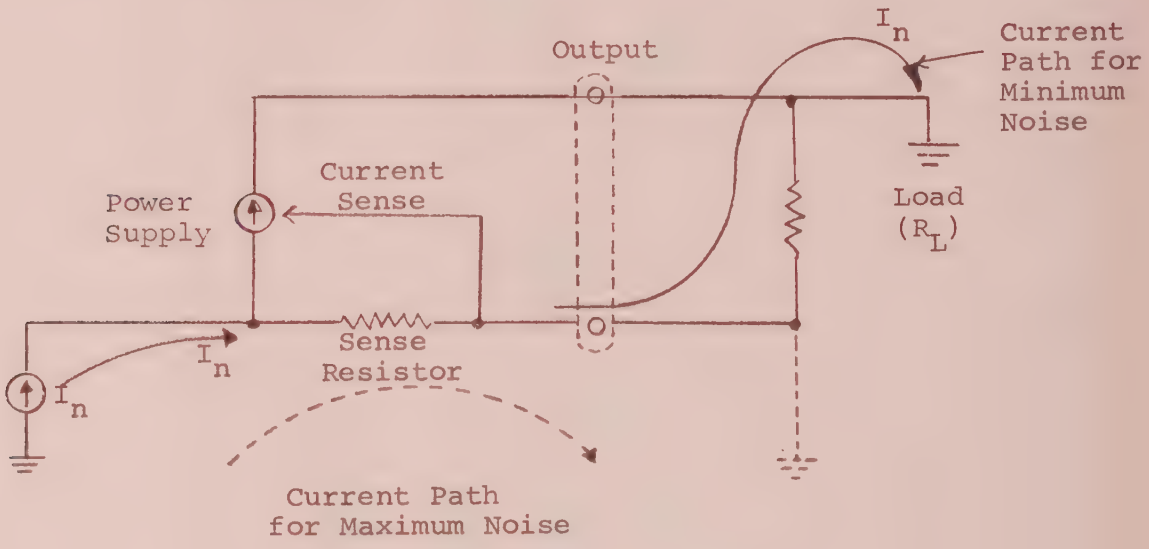


FIGURE 6.

If the alternate output terminal is grounded then the noise current will be sensed and corrected for, even though it is not a part of the output current. The correction current (equal and opposite to the noise current) will cause a noise voltage of $E_n = I_n R_L$ to appear at the load and the noise will be at a maximum.

Specifications and Tests

1. Specify the Noise Current

The current is the offender and is also the parameter most easily tested. Specification of such as "capacitance to power line" can lead to difficulties since only a portion of the noise is caused by capacitance to the power line. In general, the sources of the noise current are sufficiently complex to make detailed specification of these sources undesirable.

Specifications and Tests (continued)

1. Specify the Noise Current (continued)

Past practice has often been to compare all the noise current to a 115 V 60 Hz power line and to calculate an equivalent capacitance to this power line. This practice is satisfactory providing that everyone understands the constraints and everyone remembers that the calculated capacitance bears little relation to the real parasitic capacitance. Present general practice is to measure the effect of the noise current into a given circuit and impedance level. Quite often the test circuit is an exact duplicate of the conditions under which the power supply will be required to operate.

2. Specify Current as Peak-to-Peak

The noise current wave form is almost never a simple sine wave, in fact, peak to rms ratios of 5:1 are common.

3. Specify the Bandwidth

The bandwidth of the noise current measurement should at least include those frequencies of interest as data and, in addition, those frequencies which would disturb following equipment (such as analog to digital converters). The need for a specified bandwidth is created by the generally high harmonic content including spikes.

Bandwidths commonly specified include 200 Hz, 1000 Hz, and 10 kHz as an upper cutoff frequency. 10 Hz as a lower cutoff frequency is generally satisfactory. The noise current specifications for instrument power supplies range from 0.10 μamps pk/pk from 10 Hz to 200 Hz as a modest requirement to 0.003 μamps pk/pk from 10 Hz to 10 kHz as a severe requirement.

Tests and Measurement of Noise Current

There are two schools of thought concerning the method most satisfactorily used to measure noise current. Both are useful and have their advantages.

The first method forces the noise current to flow through a single resistor and requires the operator to measure the resistor voltage. The current is calculated from the equation:

$$I_n = E_n/R_g$$

Tests and Measurement of Noise Current (continued)

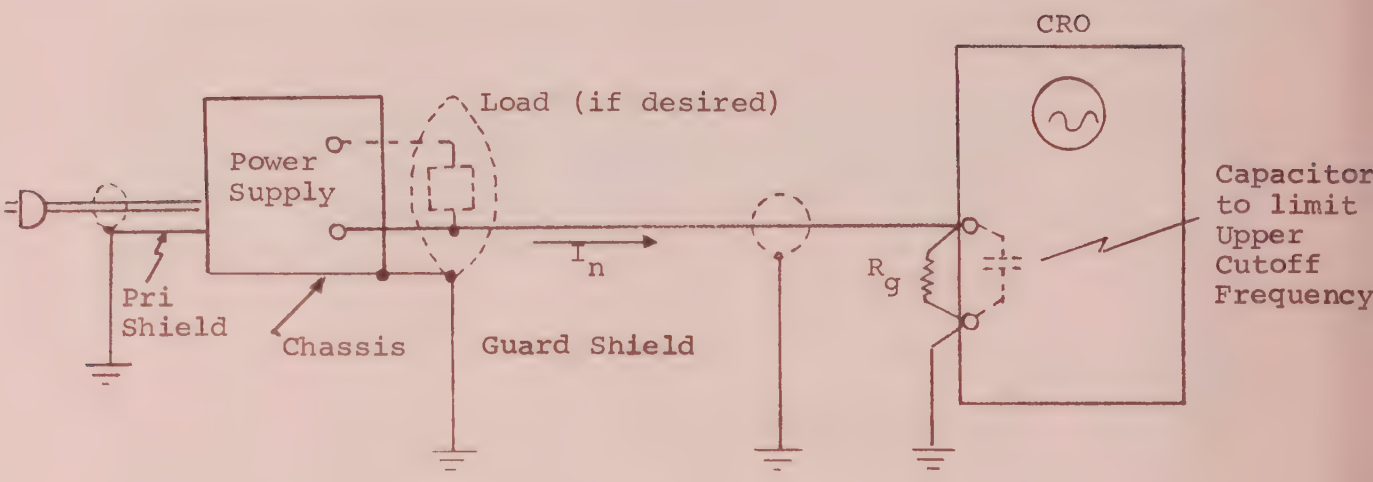


FIGURE 7.

The resistor R_g may be selected large enough to allow measurement of a reasonably high noise voltage uncluttered by thermal noise. The ability to make measurements well above the thermal noise level is the greatest advantage of this circuit. The second advantage is the ability to sort out noise current from other parasitic effects. R_g will normally range from 10 kΩ to 1 MΩ with 100 kΩ being fairly popular.

As with any test method used, it is incumbent upon the operator to reverse the AC power line connections so that a value of I_n is determined for both phases of the power line. The need to reverse the power line connections cannot be stressed too heavily. It is very common for the lower quality power supplies to exhibit gross differences in I_n. The cause of the change is linked with which side of the AC power line is grounded or near ground. For example, if the primary shield has a leak, the leak will be less noticeable if the winding in its vicinity is near ground. If the winding is well above ground, then the leak will be much more effective in generating noise current.

Any time noise current measurements are taken, there are precautions which should be observed. First, the AC power line should be well shielded and be physically distant from the output of the power supply under test, otherwise the measurement will be of the noise current generated by the test setup. Second, the output of the supply and other floating circuitry should be well shielded from stray field pickup (this includes the top end of R_g). Externally generated noise current and stray field pickup may either cancel or reinforce the apparent noise current from the power supply.

Tests and Measurement of Noise Current (continued)

A useful test for inherent noise in test circuits is to unplug the power supply from the AC power line at the power supply connector and read the noise remaining on the oscilloscope. Inherent noise should be sufficiently low to prevent interence with the test. In addition, any test setup is in trouble which is sensitive to the proximity or position of the operator. The operator should be able to bring his hand near any portion of the shielded test circuit without influencing the test results.

The second test method employs the power supply in a configuration which is similar to that in actual use. For example:

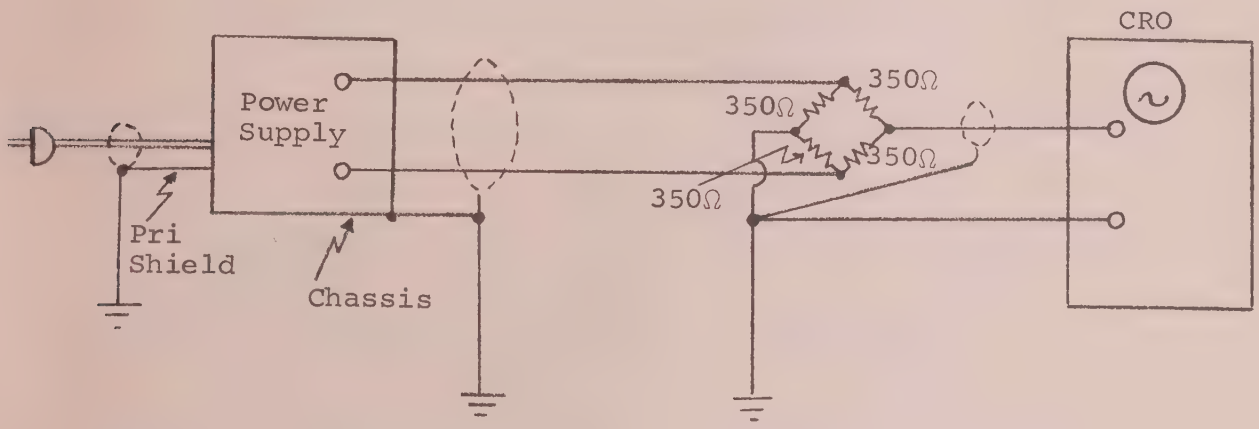


FIGURE 8.

The data is in the form of noise voltage generated on the subject bridge. An obvious disadvantage of this method is the need to measure low level data. If I_n is 0.01 μA, pk/pk and the bridge is 350 Ω per arm, then the generated noise voltage will be:

$$1/2\ I_n R_b = 1.75\ \mu V\ pk/pk$$

This figure will be difficult to measure in the face of 0.239 μV rms thermal noise (10 kHz bandwidth) not to mention noise from other sources.

The major advantage of the test circuit in Figure 8 is that the total noise of the working system may be specified as one parameter. It is unnecessary to isolate and test for several specific noise sources. This is of particular advantage if the power supply package includes bridge completion, balancing, calibration, etc., where magnetic field pickup, thermal noise, and ripple are factors of interest. A limit on the total system noise is often more useful to the user than specifications on apparently isolated parameters.

Common Mode Noise Currents

There is an additional source of noise current which is generally treated as a power supply common mode problem. If there is AC potential difference between ground and system common, then a current will flow by virtue of the existence of the parasitic capacity between the primary and secondary shield structures. The path of this current is demonstrated in Figure 9.

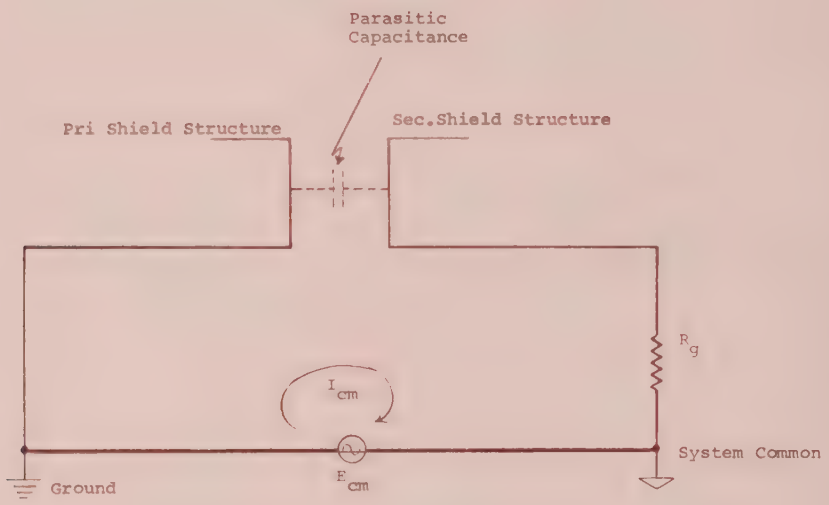


FIGURE 9.

The magnitude is defined by:

$$I_{cm} = E_{cm}\, 2\pi\, fC$$

where E_{cm} is the magnitude of the common mode voltage which appears between ground and system common, C is the measured value of the parasitic capacity, and f is the frequency of the common mode voltage. The effect of the current in this example is to generate across R_g a noise voltage $E_n = R_g\, E_{cm}\, 2\pi\, fC$. The effect on a four equal arm bridge would be $E_n = R_b\, E_{cm}\, \pi\, fC$. The equation is sometimes expressed in the form of frequency dependent common mode rejection:

$$\text{Rejection} = 20 \log_{10} \left(\frac{1}{\pi\, R_b\, C}\right) \text{ at a given frequency}$$

The difference between common mode current and previously discussed noise current is that the designer of the power supply has no control over either the amplitude or frequency spectrum of the driving voltage (E_{cm}). The effect of C can be predicted by the designer only through assumption of (or prior knowledge of) the common mode voltage.

Common Mode Noise Currents (continued)

Given sufficient volume, the power supply could be packaged in such a manner that the parasitic capacitance becomes insignificant. Space limitations and other constraints generally preclude such methods and force the designer to employ solutions involving a guard shield as in the example of Figure 10.

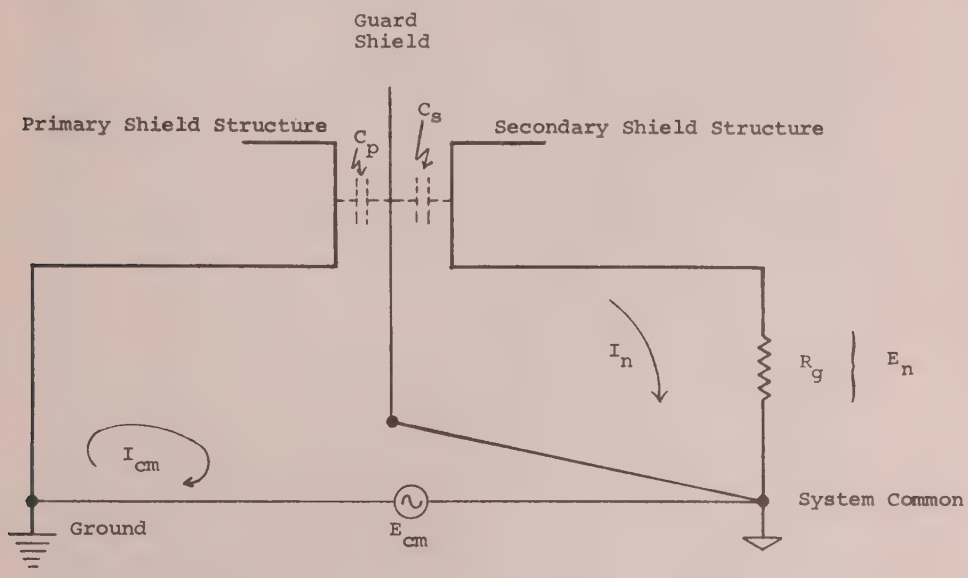


FIGURE 10.

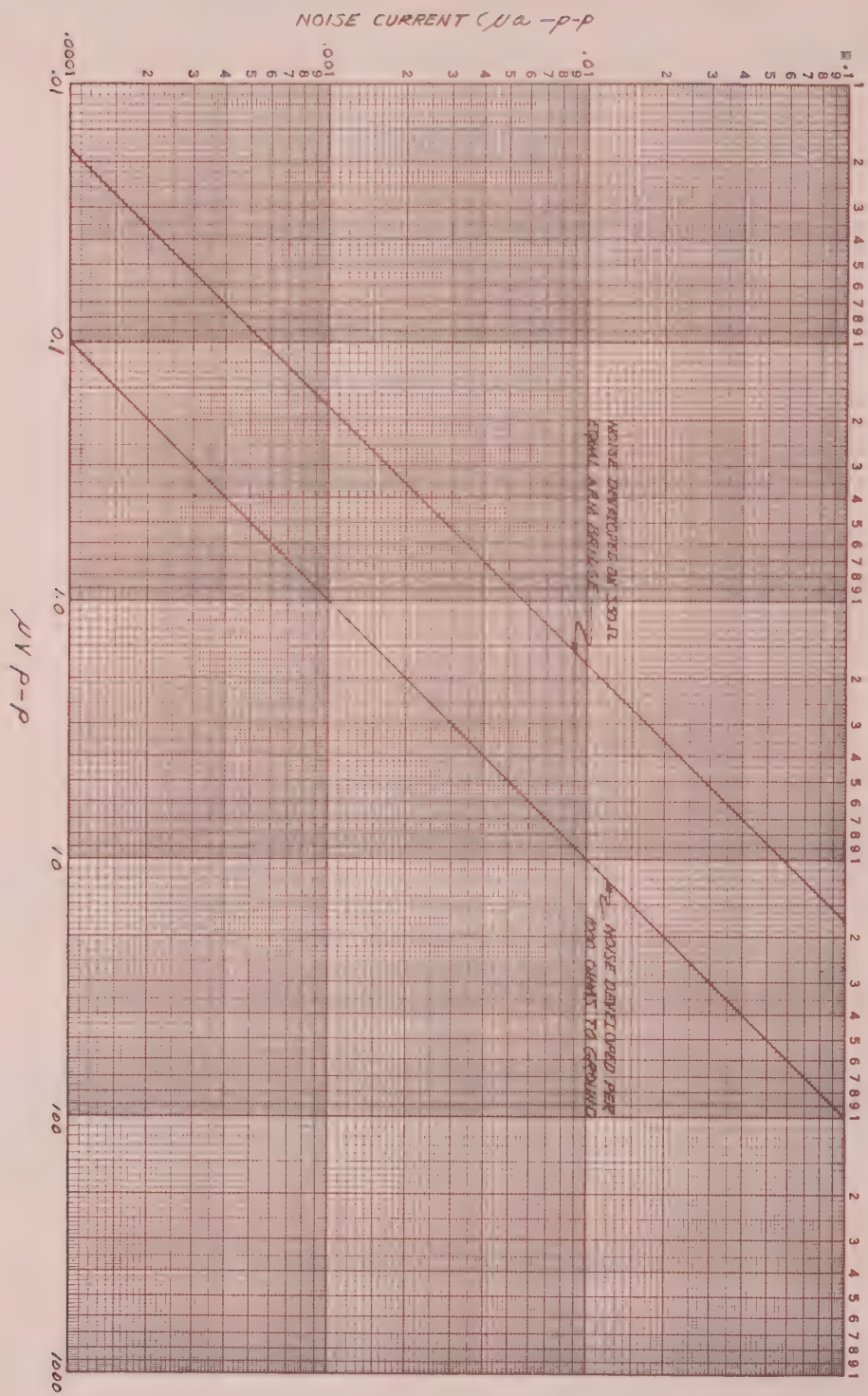
In the schematic of Figure 10, both the guard shield and the power supply output are close to the AC potential of system common. Since the voltage difference between these two is small, there can be little current flow between them. The insertion of a guard shield element between the original two, forces the common mode currents to be supplied primarily by the guard shield and through this effect reduces the effective capacitance between the primary and secondary structures. In short, that portion of the common mode current which is supplied through the guard shield does not pass through the load and does not represent noise current.

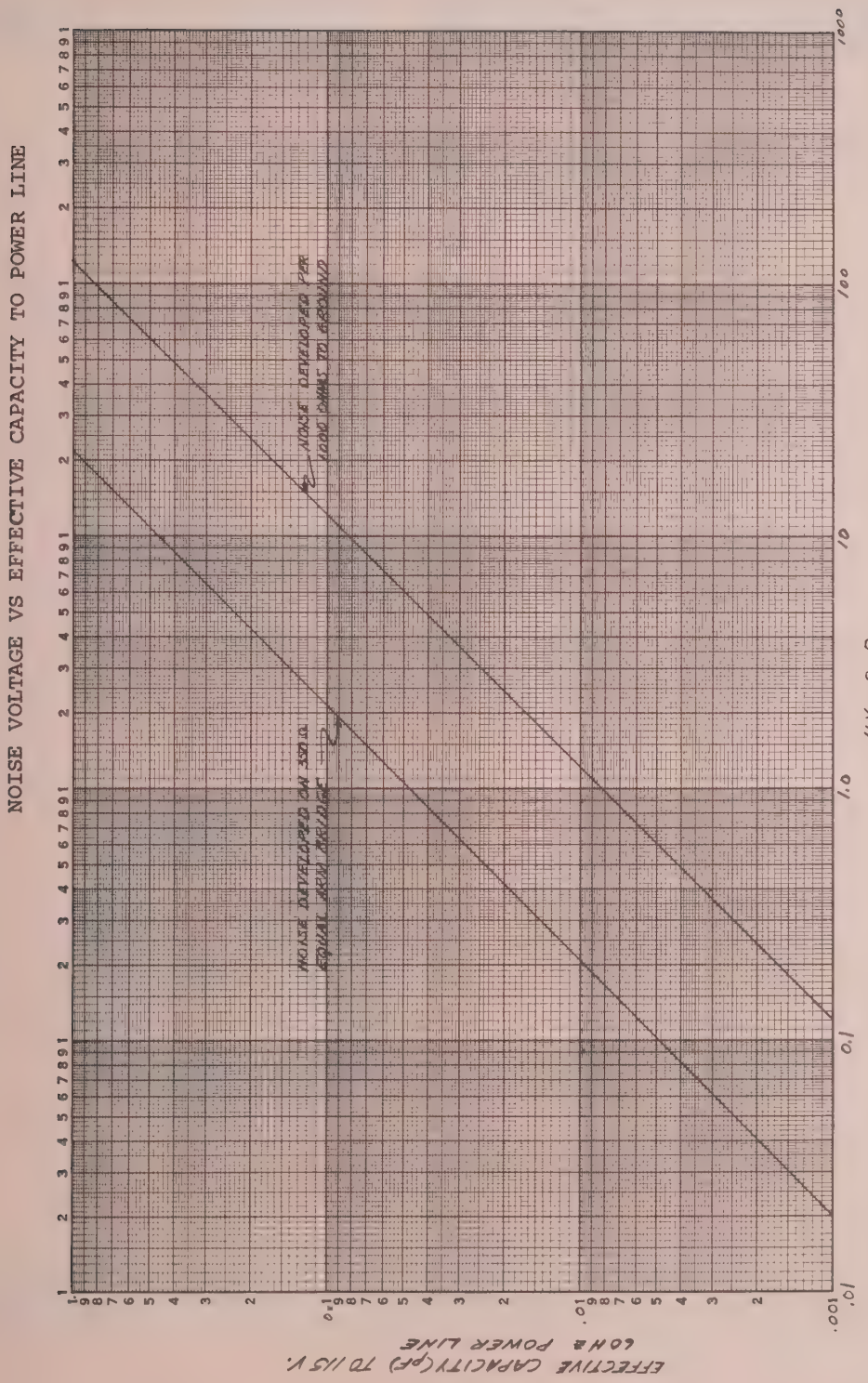
The control of common mode currents by specification is best effected by specifying the effective common mode capacitance when the power supply is used in a designated test configuration such as that in Figure 10. For testing, a sine wave common mode voltage is applied and its effect on R_g is measured as noise voltage. The effective capacitance is calculated by the equation:

$$C_{effective} = \frac{E_n}{2\pi f E_{cm} R_g}$$

Measured values of effective capacitance will normally range from 5 pF to 500 pF with 100 pF being about the minimum available without the use of a guard shield. 100 pF of effective capacitance, a common mode voltage of 1.0 V pk/pk at 60 Hz and a 350 Ω four arm bridge will result in a 6.6 μV pk/pk noise voltage.

NOISE VOLTAGE VS NOISE CURRENT




NOISE VOLTAGE VS EFFECTIVE CAPACITY TO POWER LINE
EFFECTIVE CAPACITY (μF) TO 115 V. 60 ~ POWER LINE
μV. P-P
1000
100
10
1.0
0.1
.01
.001
NOISE DEVELOPED PER 1000 OHMS TO GROUND
NOISE DEVELOPED ON 300 Ω EQUAL ANTENNA BALANCE

WARRANTY

Endevco Corporation warrants each new instrument to be free from defective material and workmanship for one year from date of shipment to the original purchaser. This warranty does not extend to units that have been misused or used in violation of Endevco recommendations, or to units that have been altered or repaired outside Endevco's factory. Defects covered by this warranty will be remedied at no charge provided this instrument is delivered to the factory with all transportation charges prepaid. If upon examination it is found that the defect is not within the scope of this warranty, a statement of repair charges and a request for authorization to proceed with repair will be submitted.

Aaron Barnett

Manager,
Quality/Reliability Control

Vice President
General Manager

ENDEVCO FIELD ENGINEERING OFFICES

NORTHEAST REGION

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